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APPLIED MECHANICS REVIEWS

VOL. 8, NO. 7 MARTIN GOLAND *Editor* JULY 1955

AUTOMATIC DIGITAL COMPUTING IN ENGINEERING

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1 INTRODUCTION

THE purpose of this paper is to discuss automatic digital computing in engineering. That is, we will discuss the processing of numbers which are represented discretely and exactly as by one of the binary states of a magnetic core. We will also discuss only computing machines which, by some form of control and organization, are such that the operator can expect at least two elementary operations in sequence without intervention. Analog computing, in which a number is represented by the measurement of a physical quantity, has an importance of its own. Similarly, nonautomatic digital computing occupies a position of prominence and usefulness in engineering. Neither will be discussed here.

Rather, we shall proceed to discuss in order: the history of digital computers, present-day digital computing in engineering, preparation of the problem for the computer, education for the use of computers, and what the future may hold for computing in engineering.

2 HISTORY OF DIGITAL COMPUTERS AND COMPUTING

The purpose of this brief history is to indicate where and when some of the significant thoughts as to machines arose, and then to indicate the rapid proliferation of machines that have been produced in the past ten years.

2.1 *Early development*

Computing is associated with the processing of numbers and arises only when a well-defined numerical process exists. Automatic computing becomes important when the well-defined numerical process must be repeated.

Well-defined numerical processes have certainly existed for at least thirty centuries, and there is evidence that man very early began to seek numerical aids of computing tools. Nevertheless, it remained for the great applied mathematicians, scientists, and engineers of the eighteenth and nineteenth centuries to provide mathematical formulations of principles of the physical sciences, while at the same time developing methods of numerical analysis. That is to say, computing in physical science began to become necessary; it also began to become possible. Computing became practical only as efficient machines were invented, and of these beginnings one must certainly mention the six digital computers of Pascal, conceived almost exactly three hundred years ago. These machines, one of which is on display in New York City, used a wheel principle for counting and could perform, when hand operated, the operations of add, subtract, multiply, and divide. There followed a number of machines and machine plans of which we shall mention only one of each because they represent a certain decisiveness from the standpoint of modern machines.

The machine plan was that of Turing and it has been used most recently by Von Neumann to describe still another machine plan which has reproducibility in some sense. The decisive machine was the Automatic Sequenced Controlled Calculator, built in the IBM Laboratories at Endicott, N. Y., and operated at Harvard University since 1944 by Professor Aiken and his associates. This machine showed the practicality of large-scale computing machines and indeed started the enormous development program throughout the world which has since ensued.

2.2 *Recent history*

By recent history we mean the past ten years, in which the following can be said of automatic computers: First, they have become an important tool to many engineers and scientists. Second, a new industry has grown up about computers with the result that dozens of new organizations have been formed, established organizations have gained new products—and all of this to design, produce, distribute, or install either computers, appropriate appendages, or their components. Third, computers have come to possess a degree of automaticity when in the hands of a sufficiently ingenious user, which has had an enormous emotional impact upon T. C. MITS.

The computers themselves can be classified roughly as small, medium, or large. Physically, small means the size of a desk, and large means that a room of at least one thousand sq ft is required to house the machine comfortably. Power-consumption-wise, small means of the order of a kilowatt, large means of the order of 100 kilowatts.

Input equipment ranges from keyboard through punched paper tape, punched cards, up to high-speed magnetic tape. Output is similar to input, but also includes high-speed printing at 1000 multicharacter lines per minute and high-speed cathode-ray tube output at thousands of coordinate points per second.

Internal processing speeds vary from a multiplication per second to floating point multiplication at the rate of several thousand a second. Amounts of storage required increase with

speed and thus may vary from 100 digits in small machines to 80,000 decimal digits of magnetic core storage in a large machine, with each number being available on a random access basis in a few millionths of a second.

Finally, control of the machines through programming may involve the use of manual switches, control panels with removable wires or pins, or, most recently, stored program. Stored program involves storing both the operation codes (1 for add, say) and the address codes (the 100th storage location, say) in the machine. Thus, at instruction time the occurrence of the number 1 100 means to the machine: "add the number in storage location 100." A principal advantage of this form of control is that addresses themselves may be modified in the machine under the control of still other instructions. Further, the possibility of programming a machine to interpret languages other than its own becomes feasible. Of this, we shall say more in a later section.

Further details, in fact, enormous numbers of details concerning machines, can be easily discovered in the literature. Our purpose here is only to indicate the wide range of available machines and, hence, pass on to a discussion of present-day problems in engineering which are being solved.

3 DISCUSSION OF PROBLEMS IN ENGINEERING PRESENTLY BEING SOLVED

There are of the order of one thousand automatic computers now in use in the United States alone, which are used either exclusively for scientific and engineering computations, or in part for such computations. Consequently, the problems being solved are numerous and varied. Our plan here is to describe the three main categories of use. These are: design, evaluation, and construction of new mathematical models.

3.1 *Use in design*

Engineering design demands imagination, new ideas, inductive reason. Consequently, computers whose most abstract operation consists of deduction based on a prior specification of alternates, cannot carry out design directly. Computers can, however, materially assist the engineer in detailing the consequences of proposed design, and it is in this area that they have found principal use.

The technical terms for the use of computers in this fashion are "parameter studies," "simulation," "mapping." It sometimes happens that a formula exists which describes the performance of a physical object, say the position of a projectile at time t, given certain initial conditions. Evaluation of the formula for each set of initial conditions, parameters, then allows the designer to use his judgment and to select appropriate values of the parameters for his purpose. The parameter study can equally well be regarded as a mathematical simulation because the designer has in effect ruled that the formula represents for his purposes of the moment, a complete description of the performance. Moreover, since the formula represents a function of the parameters, a mathematician might also say that the function has been "mapped."

The "formulas" referred to above might have, of course, been developed as specific rules for obtaining numerical solutions of equations—algebraic, differential, or integral—and we shall have more to say of this under problem preparation. Moreover, the chemical industry, which uses simulation widely as a design tool, does not necessarily have explicit mathematical formulations at all. Existing instead may be a specified sequence of physical operations to be performed, say distillation, cracking, blending. For each operation there exists from experience a set of curves which relate performance to a given operating parameter. The task then of simulating a chemical plant either involves putting the curves in tabular form and asking the computer to perform "table lookup" in its memory, or it demands that explicit mathematical representations be given for these curves (see Section 3.3).

Whatever the basis for simulation, such problems are voluminous, as illustrated by the design of a turbine, say, in which one wishes at least to consider the direct and interacting results of thrust and fuel consumption as a function of compressor configuration, burner and turbine efficiencies at various altitudes, speed, inlet temperatures, and compressor pressure ratios.

3.2 *Evaluation*

The usefulness of the computer as a simulator in detailing the consequences of a design can be very large. However, the engineer finally will build a model or a series of models using his calculated optimum parameter values. He will then test, observe the performance, and record the numerical characteristics of the performance. At this point, computation may be useful for one or more of the following purposes: Remove "noise" by a filtering procedure, determine the signal-to-noise ratio, determine the frequency spectrum, perform scaling computations, reduce the data to standard conditions of observation, summarize the results statistically, plot the final results.

Each of these operations involves such operations as add, multiply, sum the cross products, sum the squares, integrate numerically. Hence, computers are useful if the volume of work is appropriate.

3.3 *Construction of new mathematical models*

If performance data and other data representing engineering and operating data are to be used efficiently in large-scale computers, then these data must be expressed in mathematical terms. Moreover, the formulation of the "laws" of engineerng in mathematical terms has a direct importance because of its universality and conciseness. Hence, we discuss the use of computation as an aid to constructing mathematical models.

The principal methods in this direction can be stated briefly. One usually either tries to represent the empirical data by a truncated power series or by a truncated Fourier series. Failing in both, one may then face the possibility that only by proper scaling can the representation be attained. Hence, one may transform the data and hopefully start afresh. The problem of how to transform and when to transform apparently has no analytical solution and rests on the experience of the experimenter. In any case, considerable computation of a straightforward kind is usually involved.

4 PROBLEM PREPARATION

We come now to a discussion of preparing problems for the computer and to an approximate delineation between problem analysis, programming or coding, and machine operation. These three activities are not mutually exclusive, as witnessed by the fact that in some engineering computing laboratories an individual or a set of individuals may be responsible for carrying out in turn each of the activities, i.e., complete solution of a problem.

In each of these areas we will understand repeatedly that the machine is our complete and almost always faithful servant, but that it must be completely and unambiguously instructed.

4.1 *Problem analysis*

Problem analysis in preparation for computing emphasizes, particularly in the case of new problems, the need for an extraordinary combination of ability, experience, and skill. The recently announced and spectacular advances in numerical weather forecasting will illustrate.

Numerical weather forecasting uses a mathematical representation or, more precisely, a fluid-mechanics or hydrodynamic model of the atmosphere. Knowledge of meteorology and its theoretical foundations, knowledge of weather and its uncertainties, knowledge of mathematics and, in particular, of the numerical solution of partial differential equations, knowledge of computing machines and their limitations—all must be combined. How many assumptions (simplifications) can be made in the formulation and still retain accuracy? How complicated can the formulation be and still permit a stable numerical solution? How complicated can the numerical solution be and still permit the solution on existing machines in a finite time? Finally, how large will the numbers grow during the computation; what will be the effect of round-off error; what shall we do if the problem blows up?

These questions are asked for two reasons. First, because they illustrate the questions which must be answered in preparing a research problem for computation. Second, and more important, answering these questions has not only been done for the weather problem by a joint effort of scientists, universities, government, and industry, but these questions have been answered for a host of other problems of importance. The demanding combination of abilities and skills necessary for problem analysis is demonstrably present in the scientific world.

4.2 *Programming or coding*

This refers to the operation of writing, done in detail and in machine language, a statement of what specific machine operations are to be performed. It is readily apparent that programming then can begin only when problem analysis has been completed.

An example of programming for an automatic machine can be based upon the calculation of a square root of a positive fraction. Although the square root operation can be built into a machine, it is not normally done; therefore, one must write a program for square root in terms of operations, such as add, subtract, multiply, divide, store, etc. Given immediately below, then, is a mathematical statement of the Newton method of iteration in which one assumes a trial value .9999999999, and then computes successive approximations by the formula until satisfactory convergence is obtained. Following this formula is a detailed statement of the programming for the iteration scheme in terms of machine language.

$$X_n = \frac{1}{2}\left[X_{n-1} + (X/X_{n-1})\right];\quad X_n \sim (X)^{1/2}$$

Location of instruction	Instruction	Address
α	reset and add	$L(X)$
$\alpha + 1$	transfer if zero	$\alpha + 27$
$\alpha + 2$	transfer if plus	$\alpha + 4$
$\alpha + 3$	stop (manual transfer)	α
$\alpha + 4$	store	$\alpha + 30$
$\alpha + 5$	reset and add	$L(.99\cdots 9)$
$\alpha + 6$	store	$\alpha + 32$
$\alpha + 7$	subtract	$\alpha + 30$
$\alpha + 8$	shift right	1
$\alpha + 9$	transfer if zero	$\alpha + 26$
$\alpha + 10$	reset and add	$\alpha + 30$
$\alpha + 11$	add	$L(.99\cdots 9)$
$\alpha + 12$	shift right	1
$\alpha + 13$	transfer	$\alpha + 23$
$\alpha + 14$	reset and add	$\alpha + 30$
$\alpha + 15$	divide	$\alpha + 32$
$\alpha + 16$	reset and add	$L(0)$
$\alpha + 17$	long left shift	43
$\alpha + 18$	subtract	$\alpha + 32$
$\alpha + 19$	long right shift	1
$\alpha + 20$	transfer if zero	$\alpha + 26$
$\alpha + 21$	long left shift	1
$\alpha + 22$	add	$\alpha + 32$
$\alpha + 23$	store	$\alpha + 32$
$\alpha + 24$	load mq	$L(0)$
$\alpha + 25$	transfer	$\alpha + 14$
$\alpha + 26$	reset and add	$\alpha + 32$
$\alpha + 27$	store	$\alpha + 34$
$\alpha + 28$	transfer	(Out of subroutine)

In complicated mathematical problems such as the calculation of the trajectory of a missile, it is not uncommon to find several thousand detailed instructions such as just given. The length of such instruction sets depends to a considerable extent upon the ingenuity and experience of the programmer; that is, a definite amount of skill is involved in programming. One's skill can be improved with practice and education.

The most important attributes of good programmers probably are logic ability and interest in programming. Logic ability apparently is indicated by successful participation in education courses in which deductive logic is required; for example, mathematics, physical sciences, engineering sciences. Hence, at this time, laboratories seek programmers who have successfully completed education courses of study in one of those areas.

Now that several years of experience have been obtained in programming, there is a strong movement under way to reduce the detailed requirements of programming by the development of what is known as automatic programming. In automatic programming one expects, by detailed advance planning, to write a machine program which will allow the machine to understand and interpret a language which is more abstract than that processed by the machine. For example, one would like to write a series of mathematical statements and, through the automatic programming system, ask the machine to interpret the series of mathematical statements and then write a detailed program in machine language. Considerable progress is being made in this direction and it is probable that within a year it will be possible with large-scale machines to enter the machine directly with a written statement of a mathematical formula from a punched card, say.

It is clear that there are a variety of important skills, abilities, and interests demanded of the successful programmer. It is also clear that a whole new occupation has been opened because of the production of automatic computing machines.

4.3 *Operation of an automatic computing machine*

Because of the stored program control of modern computing machines, and because of the increased automaticity which a stored program machine allows—for example, automatic address modification—operation of the modern machine is also more automatic than has been possible heretofore. Consequently, it is commonplace to see a large computing facility apparently operating at full capacity and at full speed with absolutely no human intervening. This is because both instructions and numbers are loaded into the machine and the machine will then run until an error of some kind is detected, or until the problem is completed.

Errors might be of two kinds. First, an error in the information supplied to the machine in the form of an instruction or data. Second, an error in machine operation. The most important activity of the machine operator then is concerned with interpreting or locating the exact nature of an error and in knowing what to do with respect to correcting the error and starting the machine again. For this reason, the operator must be thoroughly familiar with the order code of the machine and must be thoroughly familiar with error detection and error correction procedures. It is also true that, on occasion, the operator, the programmer, and the problem analyst must consult to determine the nature of the error, and at times the engineer in charge of the maintenance of the machine must also join in the conference. Such conferences are held away from the machine because it is not efficient to allow a machine to remain idle while discussions are held concerning the cause of the error. Rather, the present problem is taken off and a new problem is put on immediately.

5 EDUCATIONAL ACTIVITIES

Because a whole new profession has been created by the existence of automatic computing machines, there is a great need

for concentrated activity to produce problem analysts, programmers, and operators. This educational activity is so important that conferences of national scope have been held and are continuing to be held to discuss it, and the results have been reported in the literature. Our only purpose here is to indicate that such activities are under way and that they are being conducted by many of the principal universities of the world, by the manufacturers of the computing machines, and finally, by the laboratories and engineering organizations which have computers installed. As is natural, and because problem analysis requires the greatest amount of abstraction and the greatest amount of theoretical knowledge and understanding, the problem analysts are being educated principally in the universities. On the other hand, machine operators are being trained principally by the facilities of the users of the equipment, with the co-operation of the manufacturers.

6 DISCUSSION OF FUTURE PROBLEMS

In Section 3 the primary discussion centered on the use of computers in engineering for design evaluation and establishing new mathematical models. There exist, however, a few clues concerning the greatest use of computers in engineering in the future. These clues indicate that problems concerning automation will be those most actively considered.

One of the most exciting examples of the use of computing in future automation has been reported by the scientists at Massachusetts Institute of Technology in connection with the automatic milling machine. In this instance, a digital computer is used to interpret the mathematical description of the piece to be milled, and then detailed instructions in terms of three-dimensional coordinates are written for the control of the milling machine. Here we emphasize the fact of *detailed* instructions.

All of us are certain that the engineering progress of the past, which has led to the present use of automatic tools in industry, will be continued and indeed accelerated in the future. The simple fact is that, with existing sensing devices, communication systems, computing machines, automatic transport devices, and automatic tools, we have all of the elements of the automatic factory. We must only tell the engineer how these elements are to be connected. Connecting elements or components into a workable system, however, is a task for which no complete mathematical or logical description exists. Experimentation and traditional trial-and-error methods must be used. Perhaps the most exciting future use of the high-speed fully automatic electronic computer will be in the area of carrying out simulations of proposed factory layouts in order that the engineers may design automatic factories on an accelerated time scale.

Books Received for Review

Csonka, P., Statika, I. II. 2nd ed., Budapest, Tankönyvkiadó, 1951, 1954, 140 pp., 230 pp. 11.50 Ft., 35.-Ft.

Csonka, P., Statikai Példatár. I. II. Budapest, Tankönyvkiadó, 1951, 1954, 200 pp., 212 pp. 17.50 Ft., 32.-Ft.

Hodge, J., Cycles and performance estimation (Gas Turbine Series, Vol. I), New York, Academic Press, Inc.; London, Butterworths Scientific Publications, 1955, xvi + 329 pp. $9.

Holowenko, A. R., Dynamics of machinery, New York, John Wiley & Sons, Inc., London, Chapman & Hall, Ltd., 1955, vii + 464 pp. $7.50.

Lawden, D F., Mathematics of engineering systems (Linear and non-linear), London, Metheun & Co., Ltd.; New York, John Wiley & Sons, Inc., 1955, viii + 380 pp. $5.75.

Mills, A. P., Hayward, H. W., and Rader, L. F., Materials of construction, 6th ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xii + 650 pp. $7.50.

Samoĭlovich, A. G., Termodinamika i statisticheskaya fizika. Moscow, Gosud. Izd. Tekh.-Teor. Lit., 1953, 439 pp.

Siebel, E., and Beisswänger, H., Tiefziehen.—Forschungsarbeiten auf dem Gebiete des Tiefziehens im Auftrage der Forschungsgesellschaft Blechverarbeitung, München, Carl Hanser Verlag, 1955, 205 pp., 153 figs. DM 14.80.

Stepanoff, A. J., Turboblowers. Theory, design, and application of centrifugal axial flow compressors and fans, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, ix + 377 pp. $8.

Theoretical and Experimental Methods

(See also Revs. 1907, 1919, 1923, 1940, 1943, 1959, 2048, 2080, 2083, 2152, 2153, 2175)

1891. Burgers, J. M., Statistical problems connected with the solution of a simple nonlinear partial differential equation. I, II, III, *Proc. k. Ned. Akad. Wet.* **(*B*) 57,** 4, 403–433, Sept./Oct. 1954.

In contrast to AMR **7,** Rev. 3964, where time correlation of wavelike solutions to random boundary-value problem (statistically stationary with respect to time) of the differential equation

$$V_t + VV_y = \nu V_{yy} \; (\nu << 1) \qquad [1]$$

was studied, the present paper, together with two earlier ones [title source, **57,** 45–72, 159–169; Jan./Feb., Mar./Apr., 1954], deals with space average for random "initial value" problems (spatially homogenous), connected with Eq. [1].

It was observed that a correlation function $\overline{v_1 v_2} = \overline{v(y)v(y+\zeta)}$ can be introduced, satisfying the differential equation

$$\overline{(v_1 v_2)}_t = \overline{(v_1{}^2 v_2)}_\zeta + 2\nu \, \overline{(v_1 v_2)}_{\zeta\zeta} \qquad [2]$$

which is the well-known von Kármán equation for propagation of correlation of isotropic turbulence. Furthermore, in analogy to Loitsianskiĭ's invariant, it was found that the integral of correlation function

$$J = {}_0\int^\infty \overline{v_1 v_2} \, \alpha\zeta \qquad [3]$$

is independent of time.

Thus, while with a specific initial value $v_0(y)$, differential Eq. [1] has a uniquely determined solution with steepening front which naturally suggests the process of shock formation, with a random set of initial values, Eq. [1] has a corresponding statistical significance in that a correlation function $\overline{v_1 v_2}$ exists, which exhibits important characteristics of homogenous turbulence.

Whereas von Kármán's equation for correlation propagation has no known solution not based on some auxiliary hypothesis, the present correlation function connected with differential Eq. [1] can be obtained for each ensemble of initial value distribution without additional supposition. Asymptotic expressions to certain statistical functions (frequency function) needed for defining correlations have been obtained, at very large time and very small ν, in the form of certain integrals. These integrals in turn contain functions which are solutions to diffusion equation with moving absorbing boundary, of which, although exact expressions are not yet known, the upper and lower bounds have been determined and series developments in certain domain obtained.

Thus, in principle, it is possible to find $\overline{v_1 v_2}$ and $\overline{v_1{}^2 v_2}$ for all

values of ζ and t, and thus investigate the behavior of these functions to test certain suppositions enunciated with respect to the hydrodynamic problem. It was found that a particular similarity hypothesis applied in hydrodynamic problem becomes an automatic outcome of the asymptotic relations developed in present paper.

H. S. Tan, USA

1892. **Ödman, S. T. A., Orthogonal method for the solution of semihomogeneous boundary-value problems** (in German), *ZAMM* **34**, 8/9, 301–302, Aug./Sept. 1954.

A method is presented for obtaining a single-term approximate solution of a self-adjoint nonhomogeneous partial differential equation of two independent variables with homogeneous boundary conditions. Three orthogonal relations involving the error function are derived by means of a modified method of least squares. The method together with examples was also given by the author in a previous paper ["Studies of boundary-value problems, part I: Minimum methods for solving semihomogeneous boundary-value problems," *Svenska Forskningsinst. för Cement och Betong*, Handl. no. 20, Stockholm, 1953].

Y.-Y. Yu, USA

1893. **Contributions to the solution of systems of linear equations and the determination of eigenvalues,** *U. S. Dept. Comm., Nat. Bur. Stands., appl. Math. Ser.* **39**, iii + 139 pp., 1954. $2.

Contains seven papers and is a sequel to "Simultaneous linear equations and determinations of eigenvalues" [AMR **7**, Rev. 2736]. The first, entitled "Practical solution of linear equations and inversion of matrixes" by L. Fox, is a valuable aid for computers. Emphasis is on elimination (direct) methods, though some attention is devoted to iterative procedures associated with the names of Gauss and Seidel. Theory for numerous direct procedures is developed. To illustrate, paper gives 26 worked examples (usually for matrixes of order 6) with complete computational layout and full details. A paper by A. I. Forsythe and G. E. Forsythe reports some punched-card experiments with accelerated gradient methods. Papers by Todd, and Savage and Lukacs deal with finite segments of Hilbert matrix. Fan and Hoffman report on lower bounds for the rank and location of eigenvalues of a matrix. Inequalities for eigenvalues of Hermitean matrixes is the subject of a paper by Fan.

Y. L. Luke, USA

1894. **Kappus, R., Solution of equation of third and higher order** (in German), *Stahlbau* **23**, 3, 60–63, Mar. 1954.

1895. **Arzhanikh, I. S., Application of functions of complex variables to the dynamics of material points** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96**, 1, 21–24, May 1954.

Contrary to Whittaker's ["A treatise on the analytical dynamics of particles and rigid bodies," Cambridge, IV ed., p. 332] method (problems of Liouville's class), author shows that the equations of relative motion of a particle, $\ddot{x} = U_x + 2\omega\dot{y}$, $\ddot{y} = U_y - 2\omega\dot{x}$, possess, except the integral of energy, a linear and a nonhomogeneous quadratic integral in the velocities.

Taking into consideration the integral of energy, there are deduced the relations between the above equations of motion and the functions of complex variables.

For $\omega = 0$, it is shown that there exists a homogeneous quadratic integral in the velocities. The problem is generalized, by aid of isothermic coordinates, for the system with two degrees of freedom, whose Lagrangian function does not depend explicitly on time.

These results are applied to an example with central motion, and there is indicated, without proof, that given relations are valuable for the motion of a rigid body about a fixed point, too (after elimination of cyclic velocities).

D. Raśković, Yugoslavia

1896. **Tables of Whittaker functions, Rep. no. 8, Numerical Computation Bureau,** published by The Tsuneta Yano Memorial Society, Tokyo, 1954, 39 pp.

Whittaker functions can be taken as standard form of confluent hypergeometric functions. Wave function in a Coulomb field is given by $W'' + [-1/4 + k/z - l(l+1)/z^2]W = 0$, l an integer. For an understanding of notation and properties of functions, reader should consult "Modern analysis" by E. T. Whittaker and G. N. Watson. See also "Die Konfluente Hypergeometrische Funktion" by H. Buchholz, and "Higher transcendental functions," vol. 2, by A. Erdélyi, et al. [AMR **7**, Rev. 1366]. Solution regular at $z = 0$ is denoted by $M_{k,l+1/2}(z)$. This and derivative are tabulated for $l = 0$, $k = 0(0.05)1.0$, and $z = 0(0.1)5.0$ to 6d. Also tabulated are functions related to $W_{k,l+1/2}(z)$ and its derivative. Latter functions vanish as $z \to \infty$. Related functions selected are nonvanishing but finite as $z \to \infty$. These are also given to 6d for same k as above and $l = 0$ for $z = 5.0(0.2)25.0$. Entries for integer $l \neq 0$ and other values of k can be obtained from present values by recurrence relations. To facilitate interpolation, second central differences in both x and k directions are tabulated for each entry. On p. 37, read u_k, v_k for uk and vk. Also read $y = 0.01$, etc., instead of 0.1, etc.

Values cut new ground in tabulation of confluent hypergeometric functions. Report suffers from several defects. No references to literature are presented. No mention is made of previous tables. Method of computation and checks used (if any) are not given. Some formulas are given (p. 3), but three are wrong. Eqs. (1) are correct if M is replaced by W. The second of Eqs. (3) should read

$$(l-k)v_{k,l} = [(2l^2/z) - k]v_{k,l-1} + l(-1/2 - 2l^2/z^2 + 2k/z)u_{k,l-1}$$

For a complete set of recurrence relation, see Buchholz op. cit., pp. 81–82.

Reviewer has spot-checked several entries and these were correct. If all entries are valid, tables are valuable.

Y. L. Luke, USA

1897. **Boas, R. P., Jr., Entire functions,** New York, Academic Press, Inc., 1954, vii + 276 pp. $6.

An analytic function is a function differentiable at every point of a region. If this region is the entire complex plane ($z = x + iy$), then $f(z)$ is called entire. The study of entire functions is a special topic in the general theory of analytic functions; nevertheless, a vast literature is devoted to such functions. It is fortunate that the author, an expert in this field, was willing to interrupt his own researches long enough to gather and organize some part of the material scattered through the mathematical journals.

Let $M(r) = \max |f(z)|$ on the circle $|z| = r$, let $m(r) = \min |f(z)|$ on this circle, and let $n(r)$ be the number of zeros of $f(z)$ inside this circle. One objective is to seek relationships among these, and other related quantities for an entire function. It is impossible in a short review to indicate the tremendous number and variety of results which can be obtained. We cite a few examples. If the order of $f(z)$ is defined by $\rho = \limsup (\log \log M(r)/\log r)$, then ρ can be expressed in a simple way in terms of the coefficients of the Maclaurin series expansion for $f(z)$, and $n(r)$ can be bounded in terms of ρ. If ρ is finite, τ, the type of $f(z)$ is defined by $\tau = \limsup r^{-\rho} \log M(r)$. If $f(z)$ is an entire function of order not exceeding 1/2 and type 0, and if it is bounded on some ray, then it is a constant.

If $\rho = 1$ and τ is finite, then $f(z)$ is said to be of exponential type; and the major part of this text is devoted to this special subclass of entire functions. For these functions, $h(\theta) = \limsup r^{-1}f(re^{i\theta})$, as $r \to \infty$ is called the indicator function, and many properties of $f(z)$ can be inferred from $h(\theta)$. There is a beautiful relation between the indicator function and the geometry of plane convex sets, which is presented clearly and in complete detail for the first time in an English textbook.

No applications to engineering or physics are mentioned in this text. The last chapter, entitled "Applications," is devoted to a select number of applications of the previously developed theory to other branches of pure mathematics.

A. W. Goodman, USA

1898. Olver, F. W. J., The asymptotic expansion of Bessel functions of large order, *Phil. Trans. roy. Soc. Lond.* (*A*) **247,** 930, 328–368, Dec. 1954.

Theory of a previous paper [AMR **8,** Rev. 1541] is applied to Bessel's differential equation to produce uniform asymptotic expansions of the function $J_\nu(\nu z)$, $Y_\nu(\nu z)$, etc., and their derivatives in terms of Airy functions when $|\nu|$ is large. Results are used to obtain new series for the zeros and associated values. Distribution of zeros of functions of large order in the z-plane are studied. A few complex zeros of $Y_3(z)$ are evaluated as an example. Technique gives reasonable value for smallest complex zero of $Y_1(z)$. This is quite remarkable, since theory postulates that order is large. To facilitate rapid calculation of smaller complex zeros of $Y_n(z)$, $Y_n'(z)$ and the Hankel functions and their derivatives, when $2n$ is an integer, some tables of auxiliary functions are given.

Y. L. Luke, USA

1899. Berghuis, J., A table of some integrals, *Math. Centrum Rep.* R 245, 8 pp., 1954.

Report contains tables of ${}_0\int^z v^n \tan v\, dv$, ${}_0\int^z v^n \cot v\, dv$ and similar integrals where circular function is replaced by like hyperbolic function. For former, $n = 1(1)5$, $x = 0(0.05)1.50$. For latter, $n = 1(1)4$, $x = 0(0.02)1.98$. Tabulation is to 8d and accuracy is better than three units of last place. Information concerning interpolation is lacking. For an application of second integral above, see AMR **7,** Rev. 1371. Y. L. Luke, USA

1900. Computer development (SEAC and DYSEAC) at the National Bureau of Standards, Washington, D. C., *Nat. Bur. Stands. Circ.* 551, 146 pp., Jan. 1955.

The book contains eight papers written by various members of the NBS staff. All papers are concerned with the design and operation of the SEAC and DYSEAC computers.

The SEAC is described in the first paper. Its over-all operating characteristics, the characteristics of each of the major components of computer, the circuitry, physical construction, and a summary of its operating history are presented. The dynamic circuitry techniques used in the SEAC and DYSEAC are then described in the second paper. Operating characteristics and the design of the tube package, dynamic flip-flop, delay line, and pulse amplifier are discussed.

The third paper presents a very complete discussion of the DYSEAC computer. Included are discussions of the addressing system, over-all functional organization, physical characteristics, and operating characteristics. An appendix to the paper includes a description of all instructions used in the computer.

The fourth paper discusses, in order, the steps followed in the system design of the SEAC and DYSEAC. These steps were: (1) development of system specifications, (2) development of detailed functional plans, and (3) development of wiring plans.

The next two papers describe the memory and input-output systems and devices used with the two computers. Included are discussions of the mercury delay line memory system, the cathode-ray tube memory system, the diode-capacitor memory system, the cartridge loading wire recorder mechanism, and the magnetic tape units.

The last two papers present discussions of the operational experience with the SEAC. A breakdown is given of the computer usage time and of the vacuum tube and germanium diode reliability experience. Diagnostic and maintenance procedures used are also described.

All papers are well written, and a wealth of information is contained in the book. It would be a worth-while addition to any computer engineer's bookshelf. L. D. Findley, USA

1901. Hoffman, A., Mannos, M., Sokolowsky, D., and Wiegmann, N., Computational experience in solving linear programs, *J. Soc. indust. appl. Math.* **1,** 1, 17–33, Sept. 1953.

Paper, written early in 1953, discusses the authors' computational experience with three methods for solving linear programming problems and compares the relative merits of each method with respect to a selected set of problems.

Linear programming refers to a class of optimization problems dealing with the maximization (minimization) of a linear functional (form) subject to a system of linear inequalities. Many important industrial applications of linear programming techniques have been made in recent years, so that the authors' discussion of their computational experience in solving such problems was both timely and instructive.

The three methods discussed are: (a) the Dantzig "simplex" method, (b) the fictitious play method of George Brown, and (c) the relaxation method of T. S. Motzkin. The simplex method is a finite algorithm which is now being used quite extensively in either Dantzig's early form or in a modified form. The Brown method is an infinite process which finds the linear programming solution by means of finding a solution to an equivalent zero-sum 2-person game in normal form. The Motzkin method is an infinite process for solving a related system of linear inequalities.

The authors' conclusions are that the simplex method is outstanding for solving problems involving matrixes of 7×7 or greater and where four or five decimal digits are required in the answer. On the other hand, the infinite methods are very useful for "small" problems where the precision demanded is either very large or very small.

The reviewer would like to point out that these comparisons are made on the basis of solving any one problem. However, besides the relative computational advantages of the simplex method as pointed out by the authors, perhaps a more important feature is that the solution matrix (i.e., final tableau) as obtained by the simplex method yields many important by-products and enables one to solve similar problems under changing conditions (i.e., modified or additional restrictions, a new set of coefficients, etc.) without the necessity of starting the solution completely anew. E. L. Arnoff, USA

1902. Mayer, M. A., and Fuller, H. W., Two new electronic analog multipliers, *Rev. sci. Instrum.* **25,** 12, 1166–1172, Dec. 1954.

1903. Koenig, E. C., and Schultz, W. C., How to select governor parameters with analog computers, *Control Engng.* 1, 4, 54–55, Dec. 1954.

1904. Moore, R. C., The McIlroy fluid network analyzer, *Instruments Automation* **28,** 3, 428–429, Mar. 1955.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1895, 2053)

1905. Szabó, I., Introduction to technical mechanics [Einführung in die Technische Mechanik], Berlin, Springer-Verlag, 1954, xii + 383 pp., 484 figs. DM 19.50.

This book has its origin in the lectures given by the author for first-year students at the Technical University of Berlin-Charlottenburg. The organization and content of the book are to a large extent determined by the requirements in parallel subjects in the first-year engineering curriculum at that institution. Since the purpose of the book is to introduce the reader to the whole subject of mechanics, the fundamentals of hydromechanics and similarity mechanics are included. Care is taken to achieve sound formulations of statements and a clear understanding of the role played by the assumptions made. Prior to the considerations of the fundamental notions of theoretical mechanics, the concepts of scalar and vector quantities, elements of vector algebra and of vector calculus are given (17 pp.).

Chap. 1 deals with statics of rigid bodies including the beam (62 pp.). Chap. 2 treats some elementary problems of the theory of elasticity, such as bending, extension and torsion of beams, Saint Venant's principle, a beam on a yielding support (railroad rail), bending of a thin-walled cylindrical beam with axisymmetrical loading, torsion of cylindrical and rectangular bars (92 pp.). Chap. 3 deals with statics of systems of rigid bodies: plane frames, trusses, and cables (27 pp.). Chap. 4 expounds the principles of dynamics (kinematics and kinetics): Newton's laws of motion, motion of the centroid, momentum of a mass system, plane motion, free and constrained motion, relative motion, gyroscopic effect (59 pp.). Considerable space is devoted to problems of friction (28 pp.), mechanical vibrations (30 pp.), and impact (17 pp.). The last part of this chapter is a study of ideal and viscous fluids (34 pp.) and the simplest similarity laws (Reynolds, Cauchy, Froude, 11 pp.).

The book is written in the best tradition of German authors [A. Föppl (1854–1924), L. Prandtl (1875–1953), G. Hamel (1877–1954), and others] for presenting texts on theoretical and applied mechanics. Analytical as well as graphical methods are used. There are 77 illustrative examples completely solved. The text is enriched by an abundance of historical notes distributed throughout the book. The printing and the explanatory diagrams are very good. In the opinion of the reviewer, this excellent book is a welcome addition to the list of textbooks in the field of mechanics, and the study of it can only be highly recommended. E. Leimanis, Canada

1906. Becker, R. A., Introduction to theoretical mechanics (International Series in Pure and Applied Physics), New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xiii + 420 pp. $8.

This book has evolved from a course given for undergraduate and incoming graduate students at the University of Illinois. It covers about the same subject matter as usually taught at a European technical university in a general course on theoretical mechanics.

In the first chapter, the elements of vector analysis, which is employed throughout the text, and Newton's laws of motion are discussed. Then follow four chapters dealing with statics of particles, rigid bodies, and suspended strings, as well as the application of energy methods in statics. The principle of virtual work is stated, but not derived generally. The remaining 10 chapters are devoted to dynamical problems of single particles, systems of particles and rigid bodies, the last three dealing with the more sophisticated methods, such as Lagrange's and Hamilton's equations, and normal coordinates in vibration problems with several or many degrees of freedom. In appendixes, the elements of ordinary differential equations and Fourier series are given.

The book is written concisely, but clarity has not been sacrificed. Its emphasis is toward the solution of problems. In the text, upward of 80 worked examples help to clarify the application of the principles involved, and each chapter is followed by a number of problems, altogether some 400. Some topics are included which are not usually dealt with in such a book; e.g., nonlinear vibrations and motion of a body the mass of which varies, the treatment being, of course, only superficial.

Comparing the book with the books of Föppl ("Vorlesungen über technische Mechanik," vols. I, IV, and VI), well known on the European continent and having about three times the size of the present book, the main differences appear to be that hydrodynamics and hydrostatics are omitted from the present book and that Föppl devotes more attention to mechanical-engineering applications.

In summary, reviewer is of the opinion that the book will form a good concise introduction for engineering and applied-physics students. F. J. Plantema, Holland

1907. Kraus, R., Technical mechanics [Technische Mechanik], vol. 1, Berlin, Verlag Technik, 1953, 336 pp., 210 figs. DM 24.

Two books are contained in this one volume. First book: Introduction to technical mechanics. Second book: Graphical statics of trusses and mechanisms.

This work is primarily intended as a textbook for the student in engineering. The first book covers: 1 Mechanics of physical points (kinematics, statics, dynamics, and dynamics of a system of points). 2 Mechanics of solids in a plane (kinematics, statics, dynamics). 3 Mechanics of bodies in spherical motion (kinematics, statics, dynamics). Most emphasis is placed on dynamics of solids in a plane. Vibration is only casually mentioned. Impact chapter is very short. It is assumed that the student is familiar with vector analysis and basic calculus. The book is based on vector analysis and almost entirely on graphical methods.

In 137 pages the author handles all basic problems of mechanics in a slightly different manner than usually found in textbooks. He tries to be very systematic, but shortness of the book and abundance of graphical methods with some very complicated graphical constructions make this text more valuable for someone who already knows basic mechanics and desires to improve his graphical methods. The book concludes with 47 well-chosen problems with numerous subvariants.

Contents of second book are: 1 General structure of body joints, notion of degree of freedom, joints, mechanisms and trusses. General degrees-of-freedom equations for space and plane structures. 2 Statically determinate trusses; plane trusses, space trusses. 3 Mechanisms; mechanisms in space, mechanisms in plane. 4 Statics of statically determinate plane structures: general, statics of plane trusses, statics of plane mechanisms. 5 Statics of structures in space; statics of space trusses, statics of space mechanisms. This is a well-systematized treatise of advanced statics.

Almost half of the book is dedicated to general classification and description of mechanisms and trusses. Second half is for graphical solutions of problems. Author bases his classification on degrees of freedom. At first he classifies all possible joints in a plane and in space according to degrees of freedom, and analyzes whole structures by their joints and link elements and their degrees of freedom. In general, all systems with number of freedom $v < 0$ are statically indeterminate trusses, with $v = 0$ statically determinate trusses, and with $v > 0$ mechanisms.

Graphical solutions in a plane are based on funicular polygons through three or more given points. Author proves usefulness of this method. Space problems are solved with force projections on two perpendicular planes with the condition that no moment exist about the line section of the planes. Mechanisms are statically solved by applying as many couples or forces as there are freedoms in the mechanisms, or by adding additional links which reduces the freedom to zero.

Author creates a general system for structures (trusses and mechanism) which enriches the general theory. Only the extent of practical application of the statical graphical solutions of mechanisms is questionable.

Book makes good exterior impression; the paper could be better. No table of errors is given. Some errors in important formulas (mass inertia for hollow cylinders) remain unnoticed. Index in both books could be arranged more carefully.

A. L. Nasvytis, USA

1908. Vonica, I., A remarkable case of an incomplete (inexact) solution to a classical problem of mechanics (in Romanian), *Gaz. Mat. Fiz.* (*A*) **6**, 164–170, 1954.

A problem of elementary statics: Two cylinders rest upon two smooth inclined planes and press against each other.

O. Bottema, Holland

1909. Signorini, A., On the motion of a rigid body (in Italian), Convegno Inter. di Geometria Differenziale, Italia, 1953, pp. 274–282, Edizioni Cremonese, Roma, 1954.

General considerations on the motion of a rigid body about a fixed point. Two problems are discussed: to determine the motion if the components of the angular velocity along fixed and moving axes, respectively, are given as functions of the time.

O. Bottema, Holland

1910. Grodzinski, P., and M'Ewen, E., Link mechanisms in modern kinematics, *Proc. Instn. mech. Engrs.* **168**, 37, 877–888, 1954.

A brief history and present state of the art of using linkage mechanisms in two and three dimensions outline the attempts of classification, their geometric treatment by the German school of Grübler and Burmester, their analytic treatment by the Russian school of Chebíshev and Bloch. Several applications are shown in which, for simpler fabrication, they replace cams. A selected bibliography of about 40 works is given. The lively international communicated discussions emphasize the active Russian interest, the paucity of work in English, the need for further examination of three-dimensional possibilities, and the reluctance to take time to design linkages to replace cams.

M. Goldberg, USA

1911. Schnarbach, K., Linkages with an oscillating follower having great travel (in German), *ZVDI* **96**, 9, 279–281, Mar. 1954.

Paper treats the kinematical design of linkages characterized by (a) extremely large travel of the oscillating follower and (b) sufficiently smooth transmission of motion. Three typical examples, two 6-bar and one 8-bar mechanism, are represented. Travels up to 270° of the driven member are obtained with acceptable angles of motion transmission. In order to accomplish greater rotary follower travels, it is necessary to maintain, during the whole cycle, the relative positions of the transmitting link within prescribed limits with respect to the driven member.

In principle, it is well known that followers with great travel angles can be generated by the use of linkages with more than four members [see, e.g., K. Hain in *Angewandte Getriebelehre*, 269–270, 1952]. The practicing engineer will benefit from the proposed mechanism arrangements which are shown in skeleton outlines.

J. Boehm, USA

1912. Baratta, F. I., and Bluhm, J. I., When will a cam follower jump, *Prod. Engng.* **25**, 7, 156–159, July 1954.

Analytical study of problem of how profile, flexibility, mass, and rotary speed determine when a follower will leave the surface of the cam (jump). Compilation of data for three different cam forms [parabolic, harmonic, and cycloidal (without initial acceleration)]. Data are intended to give a guide for determining whether or not a basic design is susceptible to jump. In this way, parameters can be changed to correct such conditions.

P. Grodzinski, England

1913. Kloomok, M., and Muffley, R. V., Plate cam design, *Prod. Engng.* **26**, 2, 156–162, Feb. 1955.

Article discusses the known basic relationships between rise of a cam, velocity, and acceleration and presents the relationships for different laws, i.e., cycloidal (without initial acceleration) and harmonic motions, 8-power polynomial motion characteristics. It is shown how these data can be applied most usefully for a profile synthesis. Two examples are given: Scotch yoke motion (cyclical fall, rise, fall, rise), and a cam operation movement (dwell, rise with acceleration, rise with constant velocity, rise with deceleration, fall and dwell). The profiles are selected to minimize inertia forces for high-speed operation.

P. Grodzinski, England

1914. Floor, W. K. G., Effective rolling radius of pneumatic-tyred wheels, *Nat. LuchtLab. Amsterdam Rap.* S.428, 30 pp., 1954.

The relation between the angular velocity of a pneumatic-tired wheel and the velocity of the axis parallel to the road can conveniently be defined by the introduction of an effective rolling radius. It is often erroneously assumed that this radius equals the distance between the axis of the wheel and the road. In this report it is argued that the effective rolling radius for a given tire at specified inflation pressure depends upon both the radial and tangential loads and also upon the direction in which the tangential loads act. Qualitative conclusions on the magnitude of the effective rolling radius are drawn from considerations of the deformations of the tire under specified loads.

The effective rolling radius was determined experimentally for two aircraft tires under radial loads. The results are in accordance with the expectation based upon the qualitative considerations. This is also the case for experimental results on automobile tires and on aircraft tires obtained by two other investigators.

Further investigations are required to cover all possible combinations of radial and tangential loads occurring in practice, both for rolling and for combined rolling and sliding between tire and road.

The practical importance of the effective rolling radius is outlined. For this purpose the phenomena occurring during spinning-up of aircraft wheels in the first phase of landing are briefly discussed and the method for calculating the drag load-time history for the landing gear is outlined. It is also shown how drag loads on wheels of aircraft are produced as a result of varying tire deflections during taxiing over uneven runways. The same phenomena are observed for pneumatic-tired road vehicles running on uneven roads.

From author's summary

1915. Moreland, W. J., The story of shimmy, *J. aero. Sci.* **21**, 12, 793–808, Dec. 1954.

Work on landing wheel shimmy, undertaken at the Wright Air Development Center, is described. This consists of tests

on tire behavior, general theory, model experiments, electronic analog studies, and full-scale aircraft experiments. Theory involves five degrees of freedom. Mathematical derivation of the equations is not given. There is good correlation between the results obtained by the different methods. Some previously published theories are shown to be inadequate. Presentation is not for the specialist only; account forms an interesting review of present knowledge. D. C. Johnson, England

1916. **Halling, J., A machine for the measurement of rolling friction,** *J. sci. Instrum.* **32,** 1, 8–9, Jan. 1955.

Paper describes a machine which has been developed for the measurement of the resistance to rolling under a range of applied loading. The machine is essentially a compact compression machine in which the rolling friction is determined by the principle of the inclined plane. It has a range of loading of 20–1000 lb with a sensitivity of $\pm^1/_2$ lb. A simple modification enables the machine to be used over a greater load range but with a reduction in sensitivity. The same principles could be adopted where it is desired to measure small displacing forces acting on a system under load. From author's summary

1917. **Kudryavtsev, V. N., Determination of friction losses in bearings subjected to loads of the rotation vector type** (in Russian), *Akad. Nauk SSSR Trudí Sem. Teorii Mash. Mekh.* **14,** 53, 5–10, 1953.

Importance of the effect of "rotating vectors" on the coefficient of friction in the supporting bearings is questionable. The author himself recognizes this.

The paper is of little research value, contains nothing new. The validity of equations set by the author is impossible to check, because not all notations are explained.

V. N. Borsoff, USA

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1903, 1951)

1918. **Friedrich, H. R., A method for investigating the influence of flexibility of the mounting structure of hydraulic servo systems on the dynamic stability quality of control systems,** *J. aero. Sci.* **22,** 2, 101–106, 123, Feb. 1955.

Transfer functions are derived for servo consisting of hydraulic cylinder, electrical feedback, electrically operated valve, and load. Elasticities of connection between cylinder piston and load, and of cylinder anchorage, are taken into account, as are the inertia, etc., of the valve. It is shown that the elasticities concerned can be represented by suitable alterations to the values of cylinder oil compressibility and leakage across the piston, and effective values of these parameters are worked out. Limits of permissible gain as restricted by stability requirements are derived. Criteria for these is that when servo is used in an aircraft or missile control loop, increasing complexity of servo (as determined by presence of elasticity parameters) must not be necessarily accompanied by decrease in "damping quality" of roots for the complete loop. "Damping quality" of roots is assumed to be measured by sum of their real parts, which reviewer believes may be an oversimplification of the problem. Author rightly stresses the high importance of elasticity of mounts as regards servo performance. R. Hadekel, England

1919. **Higgins, T. J., Basic books for your control engineering library—Servomechanisms,** *Control Engng.* **1,** 4, 48–51, Dec. 1954.

This paper is a review of 73 recent books connected with control engineering. The books are discussed in 3 groups: (a) Books with emphasis on theory; (b) books with emphasis on practice; (c) miscellaneous books. Ed.

1920. **Thomson, W. T., Impulsive response of beams in the elastic and plastic regions,** *J. appl. Mech.* **21,** 3, 271–278, Sept. 1954.

See AMR **7,** Rev. 3135.

1921. **Andresen, J., and Colvin, H. F., III, Six basic servo control systems,** *Prod. Engng.* **25,** 7, 179–183, July 1954.

1922. **Sueoka, S., On a method of shortening period of gyroscope moving with high speed,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 521–526.

Paper analyzes the precessional motion of a triple-rotor gyroscopic compass. The physical system is described in principle and consists of a central pendulous gyroscope, defined by rectangular axes $OXYZ$ fixed in the rotor casing, which is connected by springs in plane OYZ to the casings of two symmetrical auxiliary gyroscopes whose centers O_1 and O_2 lie equidistant from O on the north-seeking spin axis OZ of the central gyroscope: casing axes OX, O_1X_1, and O_2X_2 remain horizontal, while spin axes O_1Z_1 and O_2Z_2 can rotate relative to $OXYZ$ in plane OYZ, thereby compressing the springs. An approximate solution of the equations of small oscillations shows that the addition of the auxiliary gyroscopes has reduced the period of precessional oscillations. Author concludes that for the case in which the ballistic deflection of the central gyroscope automatically compensates for changes in its speed and course error, the period of undamped precessional oscillations is less than $2\pi(R/g)^{1/2}$, where R = radius of the earth, the reduction being a function of the spring stiffnesses and angular momenta of the rotors. Equations of motion of damped system are briefly discussed.

L. Maunder, USA

Vibrations, Balancing

(See also Revs. 1907, 1915, 2185, 2195)

1923. **Huang, T. C., Harmonic oscillations of nonlinear two-degree-of-freedom systems,** *J. appl. Mech.*, **22,** 1, 107–110, Mar. 1955.

By means of Poincaré's well-known perturbation method, author treats motion of two masses, one of which is connected to ground by a linear spring and to the other mass by a nonlinear one, the cubic term involved, however, being small. Viscous damping may be present or absent. The frequency of the exciting force acting upon the second mass must deviate from one of the two natural frequencies only slightly, though this is not mentioned explicitly.

The resulting response curve has two separated peaks, shifting with varying amplitude in the same manner as in the single-degree-of-freedom case.

Similar questions have occupied several authors in the past years [Collatz, AMR **5,** Rev. 3024; **7,** Pipes, Rev. 2083, Roberson, Rev. 3814]. G. Plato, Germany

1924. **Basch, A., On the vibrations of a system of two degrees of freedom** (in German), *Öst. Ing.-Arch.* **8,** 2/3, 83–86, 1954.

The movement of a system of two degrees of freedom is referred to generalized coordinates q_h ($h = 1, 2$). The kinetic energy of the system and its potential energy are two positive definite quadratic forms in $\dot{q}_h$ and q_h, respectively. Author proves the

existence of two particular directions of the plane q_1, q_2, conjugate in regard to the ellipses of constant kinetic energy as well as in regard to the ellipses of constant potential energy. In regard to these directions, the movement of the system, in the neighborhood of the position of stable equilibrium, is the result of two simple harmonic oscillations. G. Sestini, Italy

1925. Mori, D., Vibrations of rectangular frame, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 551–556.

Taking advantage of symmetry, author succeeds in analyzing a vibrational problem of rather complex nature, yet of practical importance. Frequency equations for four fundamental types of transverse vibration are obtained by solving one basic boundary-value problem. The boundary conditions are simply conditions of continuity at each corner of the rectangular frame. Transcendental functions in the frequency equations are approximated by power series, which should not materially sacrifice the accuracy of the solution. Frequencies of the fundamental and second modes are satisfactorily verified by experiments. The results are believed to be useful in studying vibrating vehicle chassis. D. H. Cheng, USA

1926. Yamamuro, M., On the coupled vibration between the lateral vibration of the crankshaft and the vibration of the engine frame in an internal combustion engine, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 571–576.

By considering the elasticity of the shaft system, author calculates the coupled vibration between the lateral vibration of the crankshaft and vibration of the engine frame.

H. G. Lew, USA

1927. Fujii, S., The roles of resistances in the vibration of a rotating shaft, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 599–603.

In some cases, resistances act as damping factors; in other cases they can be exciting factors. This paper aims to give a generalized theory to clarify the position. In reviewer's opinion, a clearer explanation of the resistance term in the fundamental differential equation is desirable. B. Noble, England

1928. Tsuda, K., On the vibration of a power-transmission system having angular clearances, (3)—especially on the subharmonic resonance, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 621–624.

Conditions for the occurrence of subharmonic vibrations are obtained on a spring-mass system with angular clearance characteristics. H. G. Lew, USA

1929. Watari, A., The motion of rotating shafts supported by flexible bearings, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 595–598.

It is assumed that the mass and flexibility of a bearing act as a vibration absorber for a rotating massless elastic shaft to which a disk of finite mass is attached. A theoretical discussion is given of the slightly nonlinear differential equations of the system and of the conditions for optimum damping.

B. Noble, England

1930. Goodey, W. J., Note on the derivation of the natural modes and frequencies of a structure by the method of minimum energy, *J. roy. aero. Soc.* **58,** 524, p. 573, Aug. 1954.

1931. Baillard, M. G., Study of transverse vibration of a rod fixed at one end (in French), *Mém. Artill. fr.* **28,** 2, 403–413, 1954.

Author gives a summary of the theory of transversal vibration of built-in beams and obtains a formula for the fundamental frequency of the vibration in a truncated cone with coaxial bore, built in at the extreme part of largest radius. The formula obtained is only valid when the angle of the truncated cone is small, which happens frequently, especially in firearms.

The formula obtained contains especially the well-known formula for the fundamental frequency in hollow cylinders and the fundamental frequency in solid cones. This has been confirmed by experiments with firearms of rapid firing frequency, where special attention was given to the dispersion.

J. A. Landoni, Argentina

1932. Gere, J. M., Torsional vibrations of beams of thin-walled open section, *J. appl. Mech.* **21,** 4, 381–387, Dec. 1954.

Paper treats cases where shear center coincides with centroid such as I and Z-sections and accounts for warping of cross section. Torsional inertia and time are introduced into Timoshenko-Wagner equation for static torsion and a solution is obtained by separation of variables. The general normal function is shown to be $X_n = D_1\cosh\alpha x + D_2\sinh\alpha x + D_3\cos\beta x + D_4\sin\beta x$, where α and β are algebraic functions of the elastic and geometric constants of the beam and of the natural frequencies. General boundary conditions are given and solutions obtained for (1) both ends simply supported, (2) both ends fixed, (3) one end fixed and one simply supported, (4) one end fixed and one end free, (5) same but fixed end free to warp, and (6) both ends free. Case (1) yields a simple analytical solution. Normal functions for the other cases are more complicated, but author presents results in accessible graphical form.

The results are shown to coincide with known solutions when warping is absent and, in particular, with the solid circular shaft.

C. T. West, USA

1933. Richardson, E. G., and Tait, R. I., Measurements on the damping of flexural vibrations in rods immersed in liquids, *Öst. Ing.-Arch.* **8,** 2/3, 200–207, 1954.

Authors wish to devote attention to the frictional damping associated with viscous effects of the medium surrounding a vibrator. A method is described whereby the damping coefficient of a reed, or a rod, in air, or in a liquid, may be measured. With some justification, the measured coefficient in a liquid, less the measured coefficient in air, is equated to the frictional damping coefficient. Some slight confusion of the notations used on pp. 201 and 204 occurs. Results show that, with use of a sufficiently massive clamp, the frictional damping coefficient of a vibrator in liquid, as extracted from measured coefficients, yields a value of viscosity, calculated from an appropriate relation due to Kirchhoff, in reasonable agreement with measurement by viscosimeter.

To reviewer, the detail of the paper seems primarily of value as a warning reminder of the difficulties involved in ascertaining just which damping coefficient is measured by an appparatus.

M. J. P. Musgrave, England

1934. Uemura, M., and Takehana, M., Damped vibrations of thin beams (The effect of air resistance) (in Japanese), *Rep. Inst. Sci. Technol. Tokyo* **7,** 2, 99–112, Apr. 1953.

In the measurement of damping capacities or Young's moduli of materials, the method of lateral vibration of thin beams is often used. With respect to the damping capacities, the influence of external air resistance upon the logarithmic decrement seems to be not negligible but comparable with that of internal

friction. Therefore, this neglect of air resistance would lead to an inaccurate measurement of internal friction.

In the present work, this vibration damping of thin cantilever beams due to the air resistance is first treated phenomenologically from the standpoint of mechanical vibration, not of aerodynamics. The following nonlinear partial differential equation is formulated, introducing two kinds of air resistance, that is, viscous and hydrodynamic air resistances

$$\rho A \frac{\partial^2 w}{\partial t^2} + \xi I \frac{\partial^5 w}{\partial t \partial x^4} + p_a b \eta_1 \frac{\partial w}{\partial t} \pm p_a b \eta_2 \left(\frac{\partial w}{\partial t} \right)^2 + EI \frac{\partial^4 w}{\partial x^4} = 0$$

where ρ is the density of material, p_a the pressure of air, E Young's modulus, ξ the coefficient of solid viscosity, η_1, η_2 the coefficients of air resistances, b the breadth, I, A the moment of inertia, the area of a cross section of the beam, respectively.

An approximate analysis using Galerkin's method and the perturbation method gives satisfactory agreement with experimental results on logarithmic decrements which were obtained from a series of specimens under various air pressures.

Details of the measuring apparatus using wire-resistance strain gages are described. The apparatus was specially made for these experiments, the specimen being placed in a vacuum chamber. From authors' summary

1935. **Sacerdote, G. G., An acoustical method for the measurement of dissipative parameters of a treated vibrating plate** (in Italian), *ATA* **6,** 5, 401–407, Feb. 1955.

1936. **Kappeler, V. F., Rubber compounds as vibration damping material in machine design** (in German, with French and English summaries), *Schweiz. Arch.* **21,** 1, 8–19, Jan. 1955.

1937. **Dugan, W. J., High-viscosity silicone fluids for mechanical applications, torsional vibration dampers, fluid couplings, servo and gyro dampers, dash pot dampers, fluid springs,** *Prod. Engng.* **25,** 7, 137–143, July 1954.

Wave Motion in Solids, Impact

(See Rev. 1907)

Elasticity Theory

(See also Rev. 1976)

1938. **Yu, Y.-Y., Gravitational stresses in a circular ring resting on concentrated support,** *J. appl. Mech.* **22,** 1, 103–106, Mar. 1955.

Muskhelishvili's complex variable method is used to extend solutions of gravitational stress problems to the case of a hollow circular disk standing on edge. The equations for two-dimensional elasticity involving body forces are solved by means of a mapping function and in terms of two analytic functions, a part of which are expressed by a Laurant series.

Evaluation is made of the stress distribution at several cross sections for a ring having an internal diameter one half the outer diameter and a Poisson ratio of 0.15.

M. V. Barton, USA

1939. **Baud, R. V., Boundary conditions and their experimental realization in elastic stress problems** (in German), *Schweiz. Bauztg.* **72,** 46, 663–669, Nov. 1954.

In experiments on models, boundary conditions in model must adequately reproduce boundary conditions in large-scale object which model represents. Author explains how boundary conditions arise in classical elasticity theory, and shows that even mathematically simple conditions are often hard to reproduce experimentally. He discusses six examples of photoelasticity applied to (1) plate with uniform biaxial tension, (2) body whose profile is to be determined to give a specified surface stress, (3) high-pressure gasholder with externally fluted surface, (4) electric generator rotor, (5) gas-turbine rotor, (6) end thrust from a dam. Paper shows clearly how actual boundary conditions can be estimated, and how they can be simulated in a model.

R. L. Woolley, Iraq

1940. **Langhaar, H. L., and Stippes, M., Three-dimensional stress functions,** *J. Franklin Inst.* **258,** 5, 371–382, Nov. 1954.

The Maxwell stress functions are generalized to include steady-state temperature distributions. It is shown that these functions satisfy Poisson-type differential equations, a general solution of which is presented in terms of harmonic functions. It is established that the derivatives of these harmonic functions can be taken as constant multiples of the arbitrary functions of the Popkovich general solution of the equations of elasticity. The form of the stress-type boundary conditions satisfied by the Maxwell stress functions is indicated. In the absence of thermal effects, expressions for the Morera stress functions are obtained in terms of arbitrary harmonic functions, by using the relation between Morera and Maxwell functions that are associated with the same state of stress; then a general solution of the equations of equilibrium is presented in terms of both the Maxwell and Morera stress functions. The Maxwell-Morera tensor, whose existence for Cartesian coordinates has been recently established by C. Weber [AMR **3,** Rev. 839], is generalized, in the absence of thermal stresses, to an arbitrary coordinate system and the result is specialized to the case of cylindrical coordinates. It is also shown that the Euler minimizing equations that correspond to the complementary energy density integral, expressed in terms of the Maxwell-Morera stress functions, are the compatibility equations. Authors state that this may be useful in deriving the compatibility equations for materials with anisotropic or nonlinear stress-strain laws. G. A. Zizicas, USA

1941. **Levy, S., Determination of loads in the presence of thermal stresses,** *J. aero. Sci.* **21,** 10, 659–664, Oct. 1954.

Thermal stresses in a structure must always be self-equilibrating. Using this property the paper shows how, in the presence of thermal strains, the total axial load, bending moment, and shear force in a member may be deduced by combining the outputs of several suitably located temperature-compensated gages. The appropriate positions of these gages are given both for constant and crosswise varying thickness of the member. The formulas developed are based on Gauss' numerical integration process. J. H. Argyris, England

1942. **Bogdanoff, J. L., Note on thermal stresses,** *J. appl. Mech.* **21,** 1, p. 88, Mar. 1954.

Purpose of this note is to emphasize the utility of complex potentials in solving two-dimensional thermal-stress problems.

From author's summary

1943. **Radenković, D., Bending of a curved bar in its own plane,** *Quart. J. Mech. appl. Math.* **7,** part 4, 385–398, Dec. 1954.

This paper discusses the influence of small deflections on the forces and moments in slightly curved beams. The problem of bending and buckling of curved beams is formulated in terms of integral equations and solved by standard methods. The exist-

ence of critical buckling loads is discussed and the relation between the analysis of curved beams and initially straight beam columns is shown. For numerical analysis the integral equation is replaced by a set of linear algebraic equations. As an example, author considers a nonuniformly loaded two-hinge bridge arch. He shows that the true bending moments in the arch differ by about one third from those obtained by the usual method of structural analysis, i.e., by a method which neglects the effects of deflection. F. W. Niedenfuhr, USA

1944. Lekhnitskiĭ, S. G., Approximate determination of stresses in elastic anisotropic plates near apertures slightly deviating from the circular (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17**, 3–28, 1953.

Stress distribution in elastic anisotropic infinite plates (slices) weakened by openings is studied in this paper. An opening is defined by $x = a(\cos\theta + \epsilon\cos 3\theta)$ and $y = a(\sin\theta - \epsilon \sin 3\theta)$, where a is constant, and ϵ is a small parameter. By a proper choice of ϵ, nearly square openings with rounded corners are obtained. Depending on the sign of ϵ, these "squares" may be differently oriented. Author utilizes an approximate procedure based on a complex variable technique previously developed by Muskhelishvili and extended to anisotropic plates by the author. This technique is applied to an arbitrary load distribution on the contour of an opening and to two special cases: plate subjected to uniform tension at infinity, and to an analogous plate subjected to in-plane bending moment. E. P. Popov, USA

Experimental Stress Analysis

(See Revs. 1939, 1941, 2015)

Rods, Beams, Cables Machine Elements,

(See Revs. 1912, 1913, 1920, 1931, 1932, 1934, 1943, 1960, 1969, 1970, 1971, 1988, 1997, 2009

Plates, Disks, Shells, Membranes

(See also Revs. 1935, 1938, 1939, 1959, 1961, 1962, 1963, 1985, 1986)

1945. Candela, F., Structural applications of hyperbolic paraboloidal shells, *J. Amer. Concr. Inst.* **26**, 5, 397–415, Jan. 1955.

After a short exposition of the properties of the hyperbolic paraboloid, author gives in simple form Pucher's general equations of the stress system analysis. More especially, the warped parallelogram is studied, arising from consideration of a portion of a hyperbolic paraboloid limited by four straight generatrix. In general, the stress system is given for the following cases: (1) snow load; (2) dead load; (3) fill load. The $f_i(x)$, $f_j(y)$ functions relative to the boundary conditions are to be determined in all aforesaid cases. The finite-differences method is recommended for the more complex solution of case (2).

Some existing examples are shown of constructions in Mexico City built up as associations of the warped parallelogram.

The possibilities of the use of these shells in reinforced-concrete construction makes this work particularly interesting.

A. M. Guzmán, Argentina

1946. Gol'denveizer, A. L., Calculation of shells in relation to concentrated forces (in Russian), *Prikl. Mat. Mekh.* **18**, 2, 181–186, Mar./Apr. 1954.

Author discusses the several problems of the theory mentioned in the title, distinguishing two methods of calculation of the shell under concentrated load. The first one consists in the calculation of the shell under continuous load uniformly distributed on the small area g and assuming afterward that the g becomes infinitely small while the intensity of load increases without limit. The second method reduces to finding an integral of the system of linear differential equations which possesses definite singularities in the vicinity of the point of application of the concentrated load. The theme is treated from the mathematical point of view only.

W. Wierzbicki, Poland

1947. Solomon, L., One-dimensional problem for a helicoidal shell (in Russian), *Prikl. Mat. Mekh.* **18**, 1, 43–54, Jan./Feb. 1954.

Thin elastic shell defined by right (minimum) helicoid is analyzed. If the unit length is appropriately selected, then such surface with negative curvature is referred to its orthogonal asymptotic lines so that the pitch is 2π. Author considers asymptotics as straight generating lines (x) and helical curves (y). The equations: $\bar{x} = \text{sh}\, x \cos y$; $\bar{y} = \text{sh}\, x \sin y$; $\bar{z} = y$.

The coefficients in all the required relationships become functions of x only. The systems of equations are independent of y since the fixity conditions and the external forces are independent of this variable for a helicoid infinitely extending in both directions. The problem is confined to integration of ordinary differential equations. Only five of the six equations of equilibrium are required. The stress-strain relationships, when referred to a system of asymptotic lines, necessarily form an orthogonal lattice on a minimum surface. Other equations are: continuity relationships in terms of stress resultants and moments, and the strain-displacement relationships. The above systems are separated into subgroups according to the unknowns. General and particular solutions are analyzed for various values of x.

Author points out the applicability of Kirchhoff's theorem, Bessel's and Newman's functions, Dirichlet's problem, as well as contributions by Vlasoff and Rabotnoff. Eleven references are included. It is mentioned that this analysis was prepared under the guidance of U. N. Rabotnoff. V. A. Valey, USA

1948. Sonntag, G., Cylindrical shells with periodically variable wall thicknesses under uniform load (in German), *Forsch. Geb. Ing.-Wes.* **20**, 2, 48–50, 1954.

Author considers cylindrical shells under uniform external or internal pressure. In the introduction he states that usually no advantage is obtained compared to the cylindrical shell of uniform thickness by varying the wall thickness, but that in some cases periodically variable wall thickness may lead to a decrease of about 15% in material expenditure. The differential equation of the problem is taken from S. Timoshenko ["Theory of plates and shells," New York, 1940, p. 391], but is not solved because the author finds a way of obtaining the necessary information for the problem in question without giving an explicit solution. This is done by splitting up both the wall thickness and the radial deflection into two parts, one part [being] periodically variable in the axial direction and the other one [being] constant and equal to the corresponding quantity appearing in the case of a cylindrical shell of uniform thickness with the same material expenditure. Introducing this into the differential equation, this equation is split up and the information is obtained which leads to the aforementioned results. Finally, the special cases where a decrease in material expenditure is obtained are discussed more in detail. The variation of the wall thickness is here made so that the tube may be assumed to be built up of sections of spherical shells with reinforcements at the parallel circles of the shells, where the shells are joined together. This type of tube may give a theoretical decrease in material expenditure of 25%.

Reviewer feels, without doubting the results, that a more rigorous discussion of the splitting-up of the equation should have been given. L. N. Persen, Norway

1949. **Neuber, H., Integration of basic equation of stiffened cylindrical shells with aid of the general shell theory** (in German), *Maschinenbau-Technik* **2**, 10, 463–466, Oct. 1953.

In 1949 Neuber, starting with the equations of three-dimensional elasticity, presented a general theory of shells in tensor notation [AMR **3**, Revs. 1070, 1246]. In the present paper the general theory is specialized to obtain the equations of equilibrium of a circular cylindrical shell. The homogeneous equations governing the displacements of the cylindrical shells are solved and the Airy function of the membrane stresses is presented in series form. In the formulation of these expressions a number of invariant quantities appear and the author presents them as an advantage over the well-known existing solutions to the homogeneous equations due to Finsterwalder, Dischinger, and Flügge. No discussion of the inhomogeneous equations is presented.

A recent paper by Moe [AMR **7**, Rev. 2441] contained comparisons of the accuracy of the roots of the characteristic equations of various approximate representations of the equilibrium conditions of cylindrical shells. The value of the present paper would perhaps be enhanced if the results presented were compared to those summarized in Moe's paper.

W. A. Nash, USA

1950. **Craemer, H., Design of prismatic shells,** *J. Amer. Concr. Inst.* **24**, 6, 549–563, Feb. 1953.

Differential equations for the bending of elastic prismatic shells consisting of several thin plates intersecting at parallel edges (hipped plate construction) are derived by considering the continuity of the structure at the edges of connecting plates. The shells are supported by stiffeners normal to the edges and are unsupported longitudinally.

The equations are integrated for several single-span systems of different cross section. The author includes a discussion on the applicability of the analysis to concrete structures.

M. L. Baron, USA

1951. **Grigolyuk, E. I., Thin bimetallic shells and plates** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **17**, 69–120, 1953.

This work is devoted to the general theory of thin elastic bimetallic shells having small displacements and elastic deformations obeying Hooke's law. The form of the shell, the loading on it, and the heating relative to thickness and surfaces are considered arbitrary. The surface of contact of the layers is taken as the reference surface. It is also the surface of fusion.

Equations of equilibrium and boundary conditions are found and expressions for stresses in the layers and the formula for the potential energy are derived. The form of the solution used in the paper leads to equations of equilibrium and boundary conditions that have the same form as that for the homogeneous shells.

Derived equations relating the internal forces in the shell are not limited by the requirement that the shell be thin. As a consequence, solutions for thin shells can be found with any degree of accuracy, of which the homogeneous shell is a special case.

The theory of bimetallic shells shows that bending moments and normal forces depend on deformation as well as on the parameters of change of curvature of the fusion surface, while the twisting moments and shearing forces depend on shearing strains and curvature of twist of this surface. It appears that the relations of internal forces and deformations have the same form as for homogeneous shell when Poisson's ratio for the layers is equal and a definite relation exists between thicknesses and moduli of elasticity of the layers.

The paper concludes with an investigation of axially symmetric deformation of round plate and finite displacement of flat shells of arbitrary as well as axially symmetric forms.

The foregoing is essentially the author's résumé. Work is a comprehensive treatment of the subject, the paper being over fifty pages in length. S. Sergev, USA

1952. **Irving, J., and Mullineux, N., Rectangular plates with stringers and ribs,** *J. aero. Sci.* **21**, 12, 847–848, Dec. 1954.

Note in Readers' Forum.

1953. **Hicks, R., Reinforced holes in plates: total weight reduced by varying thickness of reinforcement,** *Engineering* **177**, 4613, 811–812, June 1954.

Author solves the problem of the stress distribution in an infinite plate uniformly loaded in one direction and containing a large hole reinforced by a circumferential rib of variable thickness. It is assumed that the flexural rigidity of the reinforcement in the plane of the plate is negligibly small and that its cross-sectional area varies in the same manner as the tangential stress around a hole in an unstiffened plate uniformly stressed in one direction. It is shown that a reinforcement of this type is more efficient than one with constant cross-sectional area in that it is both lighter and stronger. J. H. Baltrukonis, USA

1954. **Krettner, J., Calculation of oblique parallelogram plates** (in German), *Ing.-Arch.* **22**, 1, 47–54, 1954.

Introducing oblique coordinate axes corresponding to the parallelogram of the plate, author solves the problem of a free supported plate under a constant uniform load. The equation of the deflection surface is solved in such a way that the particular integral of the nonhomogeneous equation satisfies the loading, and the complementary function of the homogeneous equation satisfies the boundary conditions. W. Ornstein, USA

1955. **Kalandiya, S. I., Bending of an elastic plate formed as an elliptic ring** (in Russian), *Prikl. Mat. Mekh.* **17**, 6, 693–704, Nov./Dec. 1953.

Paper deals with a plate loaded normally to the surface when one edge is clamped and the other is free. The problem reduces to an infinite system of linear equations. Author presents the investigation of this system of equations and the methods of solution. W. Wierzbicki, Poland

1956. **Kononenko, E. S., An example of bending a thick elastic rectangular plate** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **16**, 183–192, 1953.

The body whose bending is discussed here is formed as a rectangular plate, freely supported on its perimeter. The dimensions of plate are: $d \times k \times h$. The width of the support is equal to c. The continuous load $q = F(x, y)$ is distributed on the upper surface of the plate. The case of uniformly distributed load is analyzed when $d = k = 1$, $h = 1/2$, and $c = 1/6$. The diagrams of stresses are given. W. Wierzbicki, Poland

1957. **Hasegawa, M., and Oka, M., On the large deflection of a clamped square plate under hydrostatic pressure,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 141–144.

Authors use energy method with four constants in the deflections to obtain deflections and stresses in the plate.

B. E. Gatewood, USA

1958. Vocke, W., Stress calculation for flanges of pipes (in German), *Technik* **9**, 11, 615–622, Nov. 1954.

Bending and membrane stresses are calculated in pipes and their (fixed) flanges due to internal pressure and a loading of the flanges caused by the tension of the bolts—which are supposed to be continuously distributed in tangential direction—and by the reactive forces between two flanges transmitted by an annular gasket at a radius smaller or greater than the radius of the bolts (a limiting case of the flange clamped at its outer radius is included).

Analysis of the flanges is based on the small deflection theory for thin plates $\Delta\Delta w = q/D$ and that of the pipes on the extension of this theory for cylindrical shells. The problem is radially symmetrical and thus ordinary linear differential equations result, one for the displacements normal to the pipe surface, one for the displacements normal to the flange surface, and one for the radial displacements in the plane of the flange. These are coupled by a total of 12 boundary conditions. Solutions for the stresses are given in formulas and useful diagrams.

The validity of the theory is subjected to less restrictions than in earlier work on the subject. The remaining condition, that the thickness of the flange and the pipe must be small with respect to the inner and outer radius of the flange, seems to be satisfied reasonably for most cases in practice.

J. P. Benthem, Holland

Buckling Problems

(See also Rev. 1974)

1959. Boresi, A. P., A refinement of the theory of buckling of rings under uniform pressure, *J. appl. Mech.* **22,** 1, 95–102, Mar. 1955.

Paper presents an extension of the classical theory of buckling of rings, giving upper and lower bounds for critical loads for thicknesses up to 10% of the inner radius. Agreement with previous work on thin rings is shown. Trefftz variational method is used to obtain the stability conditions. Characteristic equations which must be solved numerically are presented, but they have only one real root. The geometrical limitation of plane stress is made, but indications of extension to more general cases are given. Displacements are considered in their linear form. Important results are given in graphical form for critical values of cases of normal and centrally directed pressure.

Reviewer believes this paper is an important extension of the Trefftz method to a real problem of considerable difficulty.

T. A. Hunter, USA

1960. Horne, M. R., The flexural-torsional buckling of members of symmetrical I-section under combined thrust and unequal terminal moments, *Quart. J. Mech. appl. Math.* **7,** part 4, 410–426, Dec. 1954.

A solution is derived for the elastic buckling load of a symmetrical I-section member subjected to an axial thrust applied through the centroid combined with unequal terminal bending moments acting in the plane of the web. An energy method is employed, using an estimate of the deflected form obtained by a method of successive approximation. The solution may be obtained to any required degree of accuracy. Approximate formulas which always give conservative results are also derived.

From author's summary by J. W. Clark, USA

1961. Bijlaard, P. P., Buckling stress of thin cylindrical clamped shells subject to hydrostatic pressure, *J. aero. Sci.* **21,** 12, 852–853, Dec. 1954.

Note in Reader's Forum.

1962. Uemura, M., The buckling of spherical shells by external pressure (3rd Report: Buckling mechanism of spherical shell segments) (in Japanese), *J. Japan Soc. aero. Engng.* **2,** 6, 11–19, May 1954.

The buckling of spherical shells by external pressure, known as the so-called "Durchschlag" phenomenon, is investigated in this paper. Especially is the spherical shell segment practically important as a pressure switch for automatic control, besides being used as a part of structures. In the first chapter, some buckling processes are considered from the viewpoint of static energy, taking into account the energy barrier. In the second chapter, the depression of the buckling load observed in experiments is explained theoretically by introducing an initial deflection as a cause of jumping over the energy barrier.

From author's summary

1963. Federhofer, K., The buckling load of an axially compressed circular cylinder shell on an elastic foundation with coefficient increasing along the generatrix of the cylinder (in German), *Öst. Ing.-Arch.* **8,** 2/3, 90–97, 1954.

A theoretical study has been made of the buckling of a circular cylindrical shell provided with elastic support over its entire surface and loaded by compressive forces applied axially along the generators. The elastic support is assumed symmetric with respect to the center of any cross section and is either constant or varies linearly along a generator. Symmetric and asymmetric buckling are considered. The symmetric case is the simple one treated by Timoshenko ["Theory of elastic stability," 1936, p. 441, Eq. (266)] except that allowance is made for the elastic support. The asymmetrical case is handled with the three equations of equilibrium in displacement u, v, w given by Flügge ["Statik und Dynamik der Schalen," 1934, p. 191] mutatis mutandi. The boundary conditions in all cases studied are those usually referred to as simple support. The unsymmetrical case is further related to some work by Flügge [*Ing.-Arch.* **3,** 477, 1932]. Critical loads may be determined from the results given in the paper.

W. H. Hoppmann, II, USA

1964. Norris, C. H., and Scalzi, J. B., Local buckling of intermittently welded structural members, *Welding J.* **33,** 11, 564s–578s, Nov. 1954.

Paper, a sequel to AMR **5,** Rev. 1354, describes techniques and results of tests on limited number of intermittently welded beams and columns and considers the structural performance in terms of "gap-width ratio," a criterion proposed in the first paper. Conclusions and recommendations substantiate what designers have been guided by for years, viz: (1) Limiting length of gap to 16t between intermittent welds does not have a sound or logical basis, and critical gap-width ratio appears to be a more rational criterion; however, authors nowhere show conclusively that 16t criterion leads to unsafe design. (2) Members with intermittent welds will not take much abuse in excess of yield point, and, therefore, use of intermittent welding should be restricted to secondary members, except tension elements. (3) Local buckling resistance and fatigue strength favor use of light continuous welds in lieu of intermittent full-size welds. This is also economically desirable, considering the inordinate time required by intermittent welding in layout time and operator time-loss in starting and stopping weld beads. Appendix discusses buckling of intermittently supported rectangular plates under triangularly distributed end compressions.

G. P. Fisher, USA

1965. Goodey, W. J., Note on the stabilisation of long struts by an elastic medium, *Aero. Quart.* **4,** part 3, 279–286, Aug. 1953.

The stabilization is provided by a supporting thin web having

a small member attached to its other longitudinal edge (x-direction) and several web stiffeners in the perpendicular y-direction. Hence the strut is not only continuously supported against lateral deflections, but the shear deformations of the web are also considered. This leads to a somewhat more complicated type of differential equation than usually. Author simplifies the problem by assuming vanishing normal stresses in the web in x-direction (consequently constant shear flow over the width, and so on, $N_x = 0$; $N_{xy} = F(x)$; $N_y = G(x) - yF'(x)$).

It is reviewer's opinion that with these simple assumptions it should be possible to write down immediately the obtained formula for the critical compression load by using the well-known method of "split rigidities." F. M. Mueller, USA

Joints and Joining Methods

(See Revs. 1964, 1975, 1993, 2002, 2117, 2176)

Structures

(See also Revs. 1894, 1914, 1925, 1943, 1952, 1959, 1987, 2001, 2014, 2034, 2035, 2036, 2179)

1966. **Kersten, C., Reinforced concrete bridges [Brücken in Stahlbeton. Bd. I. Platten- und Balkenbrücken],** 8th ed. (revised by Dedering, C.). Berlin, Wilhelm Ernst & Sohn, 1953, viii + 224 pp. DM 19.

The first chapters deal with concrete and steel, their use, and standard rules concerning bridge structures, which are important for all slab and beam bridges. In the following part the various kinds of bridges are discussed, classified from statical points of view. In this edition, chapters have been added on prestressed concrete bridges, on postum joined bridges of prefabricated parts, and on rigid composite structures (T-beams composed of concrete slab on girder of steel). The prestressing methods most used in Germany are described, followed by several examples typical of the newest development. Reviewer regrets that the treatment of the bridges of rigid composite structures is very short. He suggests this chapter be enlarged in the next edition.

The author wants to show the importance of all construction details which, if well constructed, guarantee a long life and a good appearance of the bridges; e.g., the draining of water and the construction of the joints. Therefore, emphasis is put on many and good detail drawings and photos, while the text is short though clear. The book is qualified for engineering students, but the engineer with experience will also find support for his design work in this field. G. Brandes, Germany

1967. **Hognestad, E., and Janney, J. R., The ultimate strength of pre-tensioned prestressed concrete failing in bond,** *Mag. Concr. Res.* no. 16, 11–16, June 1954.

Paper discusses the results of investigations into bond. There were two major series of tests; one series was concerned with the prestress transfer bond, and the other with flexural bond stresses. The results of the tests are given in graphical form, and the relationship between the bond strength and the ultimate strength of pretensioned concrete is discussed.

From authors' summary

1968. **Friberg, B. F., Combined form and reinforcement for concrete slabs,** *J. Amer. Concr. Inst.* **25,** 9, 697–716, May 1954.

One-way concrete slab construction, designated as "re-form," is described, in which high-strength galvanized corrugated steel is both form and reinforcement for the concrete, and in which temperature reinforcement, welded to the corrugated steel, performs shear transfer. Structural tests are described and analyzed. Suggestions are given for moment distribution in slabs cracked over the supports in continuous spans. Long-time deflections of thin slabs are appraised. Design procedures and applications for re-form construction are indicated.

From author's summary

1969. **Forssell, C., Shear strength and shear reinforcement in concrete beams** (in Swedish), *Kungl. tekn. Högskol. Handl. (Trans. roy. Inst. Technol. Stockholm)* no. 78, 64 pp., 7 tables, 1954.

1970. **Savona, J. S., A circular diagram for the design of beams,** *Concr. Constr. Engng.* **49,** 5, 158–160, May 1954.

Note describes a graphical method of determining the depth of a beam subjected to a known bending moment and of calculating the stresses in a singly reinforced beam.

From author's summary

1971. **Nowinski, J., Influence of the end restraint on stress and deflection of a cantilever beam** (in German), *Maschinenbau-Technik* **3,** 7, 369–374, July 1954.

Elementary beam theory does not give a consistent picture of stress and strain at the fixed end of a cantilever beam. Author derives expression for added stresses throughout a beam of rectangular cross section to correct the elementary theory. A trigonometric and exponential form is assumed for the correction stresses and they are made to satisfy both the Navier differential equations and the conditions that they must introduce no resultant force or moment at any cross section of the beam. Stress distributions and deflections are evaluated in terms of depth-length ratios and height-depth ratios. G. Murphy, USA

1972. **Yasumi, M., Determination of section of the composite beam,** *Technol. Rep. Osaka Univ.* **4,** 65–70, Mar. 1954.

Instead of the trial-and-error method, a direct and rapid method of obtaining the most economical section in composite beams is shown. From author's summary

1973. **Ban, K., Classification of methods of solution for rigid frame under load,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 517–520.

Author classifies methods of solutions for rigid frames under load into two basic types. One is the analytic fixed-point method and the other the method of basic system. Due to the fact that the solution of rigid frames is equivalent to solving a series of linear simultaneous equations, matrixes can be used to their fullest advantage. The demarcation of the two basic types of methods is demonstrated by different approaches to the solutions of the matrixes. No practical example is given. Also, there are misprints in Eq. (3). D. H. Cheng, USA

1974. **Esslinger, Maria, Tipping of angular frames with rectangular cross section** (in German), *Stahlbau* **23,** 3, 53–60, Mar. 1954.

Author considers a flat bar in the form of an arch. Differential equations are given for torsion and lateral bending, equation containing bar length as independent variable, lateral displacement and torsional angle as dependent variables, and, as unknown constant, tipping load. Using a Fourier series for lateral displacement, the torsional angle can be written as a function of bar length and a series of unknown constants, whereby end conditions of bar are considered. This function substituted in differential equation for bending gives, finally, the desired equation for determining tipping load. Equation contains bar length and a series of unknown constants including tipping load, and is to be

satisfied at any position of bar length. Accuracy of tipping load depends on number of constants used. It is shown, by examples, that for flat bar arches the first term only of the Fourier series offers a sufficiently accurate tipping load.

Method described is applicable to frames consisting of straight and curved parts (some examples are given) and to arches with varying rigidity of the bar. E. Steneroth, Sweden

1975. Hechtman, R. A., Young, R. D., Chin, J. M., and Savikko, E. R., Slip of joints under static loads, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 484, 18 pp., Oct. 1954.

The primary purpose of this investigation was to determine the slip of structural steel double-lap joints assembled with high-strength steel bolts when subjected to stresses in the design range and somewhat beyond. The joints were subjected to short-time static loading. Although most of the joints were tested in tension, some were tested in compression and in combined compression and torsion. This paper reports the results of 72 tests, which are part of a continuing investigation.

Of the principal factors affecting the slip of the joint, those studied included such dimensional properties as the total faying area, the net cross-sectional area, the thickness of the lap plates, and the number of rows of bolts in the joints. Other properties studied included bolt tension and surface condition of the faying areas. The joints were compared on the basis of the shearing stress on the bolts, the coefficient of friction and the slip (both developed at the first major slip), and the stress on the net cross-sectional area. From authors' summary

1976. Freudenthal, A. M., On inelastic thermal stresses in flight structures, *J. aero. Sci.* **21,** 11, 772–778, Nov. 1954.

Conventional design for thermal stresses is based on an elastic analysis of the stresses and their comparison with a limiting creep rate or creep strain and a time-dependent fracture stress, which both are characteristic manifestations of inelastic behavior. This contradiction between the premises of the stress analysis and of the strength analysis necessarily leads to design procedures of considerable unreality.

The effect, on the level of thermal stresses, of inelastic behavior of the structural material, with constant and with temperature-dependent parameters, is investigated; the results are compared with those of the elastic analysis. The importance of design for inelastic thermal stresses is discussed.

From author's summary by G. Gerard, USA

1977. Joyner, U. T., and Horne, W. B., Considerations on a large hydraulic jet catapult, *NACA TN* 3203, 49 pp., July 1954.

A survey of various types of catapults, which has been made in connection with the problem of accelerating a large (100,000 lb) car along a track to a speed of 150 mph, is given. A hydraulic jet catapult is indicated as the best suited among these catapult types for the purpose intended, and various design problems of this type are treated. Equations are given for calculating the performance of the jet and of the test car, and consideration is given to the physical conditions affecting the jet flow. Design procedures are presented for the jet nozzle and for the bucket on the car which receives the jet and imparts thrust to the car.

The expected propulsive efficiency of the jet catapult is given and the effect of a side wind on the jet trajectory is calculated.

From authors' summary

1978. Hunziker, A., Self-supporting winding stairs with rigid reinforcement and horizontal annular beam (in German), *Schweiz. Bauztg.* **72,** 13, 167–171, Mar. 1954.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1920, 1933, 2004)

1979. Hu, L. W., and Marin, J., Anisotropic loading functions for combined stresses in the plastic range, *J. appl. Mech.* **22,** 1, 77–85, Mar. 1955.

Combined stress tests on tubes of an anisotropic aluminum alloy, using axial tension and internal pressure, are reported. Aim is to determine yield criterion under biaxial stress. Method is to look for stress paths during which no plastic strain is produced, and to regard the one farthest from the origin in stress space as defining the yield function.

Reviewer regards method as basically unsound; method would determine only the proportional or elastic limit, not the function defining yielding (in sense of pronounced plastic flow). It is the latter which is relevant to theories of plasticity; these are not concerned with elastic limits and hysteresis loops (except as second-order effects). Method would be sound only for an ideal metal in which the elastic limit and plastic yield point always coincided.

The same criticism applies to the authors' similar method for investigating whether or not a "yield corner" exists, viz., by loading to some plastic state and then unloading along various stress paths to see if plastic strains occur. If they did, it could indicate simply a hysteresis loop (or, in some cases, creep) and not necessarily a singular point on the yield surface. Small plastic strains would certainly be found for most (if not all) paths lying *within* the actual yield surface. The proper way to locate the yield point experimentally is as the "knee" in a stress-strain curve (and not as the elastic limit) in direct loading from zero stress. R. Hill, England

1980. Irmay, S., Dynamic behaviour of linear rheological bodies under periodic stresses, *Quart. J. Mech. appl. Math.* 7, part 4, 399–409, Dec. 1954.

Author discusses the dynamics of a generalized linear rheological body, including, as special cases, elastic and Kelvin (or Voigt) solids, Newtonian fluids, and Maxwellian fluids (or solids). Paper includes the investigation of the behavior of such a body under the action of external stresses which vary sinusoidally with time, and also transient stresses in the form of the Heaviside step function and the Dirac δ-function. The response of the body to such stresses, combined with thermodynamical considerations, leads to a classification of rheological substances into three categories, depending on the value of a nondimensional parameter which is a function of the elastic and flow properties.

R. M. Davies, Wales

1981. Batdorf, S. B., and Budiansky, B., Polyaxial stress-strain relations of a strain-hardening metal, *J. appl. Mech.* 21, 4, 323–326, Dec. 1954.

The authors review their slip theory of plasticity, and although concluding that it fits the number of experimental data quite well, there remain several phenomena which it cannot describe. The Bauschinger effect cannot be predicted explicitly by the slip theory of plasticity. Furthermore, the slip theory states that the initial shear stiffness deviates from the elastic value depending upon the ratio of the tension to the shear stress. This is particularly so for the case where the specimen is loaded in tension into the plastic region and a shear stress is added. Tests showed that the initial shear stiffness was equal to the original elastic value throughout the experiment, which is in contradiction to the prediction of the slip theory. In another test where a statistical analysis was made of the angular distribution of slip lines in the various grains of a commercially pure aluminum specimen as

compared with the assumptions of the slip theory, a wide discrepancy was noticed for high values of the slip angle. The authors conclude that further work is necessary on the slip theory before it will adequately describe the stress-strain relations of a polycrystalline metal. A. D. Schwope, USA

1982. **Rubenstein, C., The influence of creep on the measured hardness of soft metals,** *Proc. phys. Soc. Lond.* (*B*) **67,** 415B, part 7, 563–568, July 1954.

An attempt is made to extend the semi-empirical Meyer-O'Neill relation between applied load and diameter of indentation to metals under conditions of a pronounced quasi-viscous creep component. Since it seems to this reviewer that, unless the temperatures are high, the primary (work-hardening) creep component will represent the dominant effect in metals, the application of the steady-state creep equation is hardly justified.
A. M. Freudenthal, USA

1983. **Thomas, T. Y., Interdependence of the yield condition and the stress-strain relations for plastic flow,** *Proc. nat. Acad. Sci. Wash.* **40, 7,** 593–597, July 1954.

Author makes the following fundamental assumptions: (1) The stress deviation s is an invariant of the rate of strain tensor ϵ—derived from the velocity vector v—under proper orthogonal coordinate transformations; (2) the relation between the stress and strain components is *not* a (1.1) correspondence and may be regarded as expressing the essential distinction between plastic flow of solids and flow of ordinary fluids. Author establishes the general invariant form of the stress-strain relation as a sum of two members whose coefficients are functions of the two first invariants J_2 and J_3 only.

By this he obtains by specification the stress-strain relation in the theory of von Mises and also the Tresca yield condition.
Th. Pöschl, Germany

1984. **Aslanova, M. S., and Rebinder, P. A., Adsorption effects on elastic reaction and creep in glass fibers** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **96, 2,** 299–302, May 1954.

Paper represents an investigation on the action of an adsorptive active environment on the tensile properties of glass fibers. It was noticed that under the continued action of a tensile strain, an elastic reaction appears in glass fibers. The limiting value of this strain is given by $\epsilon = (\epsilon_1 - \epsilon_0)/\epsilon_0 \times 100$ in per cent, from the instant elastic deformation commences and rises sharply with an increase in the relative humidity of the atmosphere. Adding surface active constituents, which are chemically inert in so far as glass is concerned, to water still augments the elastic reaction almost 10%. In the cases considered, there appears to be a point at which there is a gradual involuntary displacement of the adsorptive molecules of the medium from the surfaces of the ultramicroscopic fractures of the fiber after the cessation of load, as well as a "self-healing" of these microscopic fractures due to the action of the cohesive forces in glass. The adsorptive effect on elastic reaction can be detected in silicate glass fibers as well as in alkaline free phosphate glass, not containing silicon dioxide.

The most noticeable effects of adsorption on elastic reaction of fibers of various glasses is produced in the following situations: (a) Aluminum borosilicate fibers in a water solution of isoamyl alcohol; (b) alkaline glass fibers in water; (c) alkaline-free phosphate glass fibers in water solutions of surface active substances, having high polarities.

Wetting fibers in a nonpolar fluid hydrocarbon is analogous to the action of dry air and produces no elastic reaction or creep.
N. M. Matusewicz, USA

1985. **Gaydon, F. A., and McCrum, A. W., A theoretical investigation of the yield point loading of a square plate with a central circular hole,** *J. Mech. Phys. Solids* **2,** 3, 156–169, Apr. 1954.

Authors apply the upper and lower bound theorems to a thin square plate, with a central circular hole, yielding under uniform normal stresses applied at its outside edges. Three loading states are examined in detail: equal biaxial stressing; uniaxial stressing; and equal, opposite biaxial stressing. The collapse loads are either evaluated exactly or upper and lower bounds are obtained. From these solutions, upper and lower bounds are obtained for a general loading state. A. Phillips, USA

1986. **Gaydon, F. A., On the yield-point loading of a square plate with concentric circular hole,** *J. Mech. Phys. Solids* **2,** 3, 170–176, Apr. 1954.

Author determines upper and lower bounds to the collapse load of a square plate, with concentric circular hole, under certain loading of the edges. The loads on opposite edges are equal; those on adjacent edges are held in a fixed proportion during each loading program. The loads are supposed to be uniformly distributed and normal to the edges over which they act, and the edge of the hole is stress free. The Tresca yield criterion and potential function are used throughout. It is found that the upper and lower bound theorems give reasonably close bounds to the collapse load.
From author's summary by A. Phillips, USA

1987. **Umemura, H., Plastic theory of reinforced concrete frame,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 331–336.

Instead of a linear relation between bending moment and curvature, a more general but not ideally plastic dependency is introduced which seems to have been obtained by experiment. This, then, is used to determine bending moments in very simple types of frames by relaxation. Reviewer, however, doubts whether this method can be applied to more complex structures in which more than one joint has to be relaxed repeatedly.
H. Craemer, Pakistan

1988. **Ohno, I., Stress calculation of curved beam in a state of yielding,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 135–139.

Paper presents elastic-plastic solution for curved beams subjected to pure bending for materials having idealized strain-hardening type of stress-strain diagram consisting of two straight lines. Method is similar to transformed section method previously considered for elastic case by Hardy Cross and others. Graphical method of locating neutral axis simplifies the solution. Final equations are put in form similar to straight-beam equations, using modified moment-of-inertia terms referred to neutral axis instead of to gravity axis. Applicability of general equations is demonstrated for special cases in which (a) modulus of elasticity in plastic range is zero and (b) entire section is within elastic range. W. E. Black, USA

1989. **Ibrahim, A. A. K., and Kabiel, A. M. I., The theory of an oscillating cylinder viscometer,** *ZAMP* **5,** 5, 398–408, 1954.

Article is a generalization of the previous work [*J. appl. Phys.* **23, 7,** 10, July, Oct. 1952] of the authors to include all values of the ratio of amplitude of oscillations of inner and outer cylinders of the oscillating cylinder viscometer. Paper shows simplifications which result under various possible experimental conditions. Results are in excellent agreement with experiment of Oldroyd, Strowbridge, and Toms [*Proc. phys. Soc. Lond.* (*B*)

64, 44, 1951]. See also analysis of Oldroyd [*Quart. J. Mech. appl. Math.* **IV**, pt. 3, 1951].

Authors seem somewhat uncertain as to best method of extrapolating experimental curve (ratio of amplitudes of inner and outer cylinders vs. forcing frequency) to determine its slope at zero frequency, and, as in their Oct. 1952 note, suggest two methods of graphical extrapolation and recommend the use of the average of the two results. Reviewer feels that a simple numerical extrapolation would be more appropriate and would eliminate the subjectivity present in the graphical techniques. The fact that the value of the function is known to be zero at the origin, where its slope is desired, would considerably aid the method suggested by reviewer. W. Daskin, USA

Failure, Mechanics of Solid State

1990. Gerard, G., Life expectancy of aircraft under thermal flight conditions, *J. aero. Sci.* **21,** 10, 675–680, Oct. 1954.

Paper deals with structural problems which arise from aerodynamic heating. A review is made of the literature and test data for cyclic stress conditions at elevated temperatures. From trends indicated by the existing data, author suggests a life-expectancy hypothesis for variable stress and temperature conditions. The hypothesis seems useful for qualitative predictions but has not been verified quantitatively.

A. B. Cambel, USA

1991. Anonymous, Static tests and fatigue tests on "Redux"-bonded built-up and solid light alloy spar booms, *Aero. Res. tech. Notes Bull.* 144, 16 pp., 1 table, Dec. 1954.

1992. Hartmann, E. C., Holt, M., and Eaton, I. D., Additional static and fatigue tests of high-strength aluminum-alloy bolted joints, *NACA TN* 3269, 42 pp., July 1954.

Additional static and fatigue tests were made on a few types of joints in 75S-T6, 24S-T4, and 14S-T6 high-strength aluminum-alloy extruded bar to supplement the data in *NACA TN* 2276. Comparisons are made with the results of these earlier tests.

A joint of new design, stepped double-shear in 75S-T6 aluminum alloy, was found to have a fatigue life less than for the plain double-shear joint or the double-scarfed joint, but greater than for the rest of the joints. For three joints studied in 75S-T6, 24S-T4, and 14S-T6 aluminum alloy, no one alloy gave consistently greater fatigue life. 24S-T4 in the plain-scarf joint gave higher fatigue life than did 75S-T6, but in the double-shear joint the 75S-T6 fatigue life was greater than for either 24S-T4 or 14S-T6. Small clearance added to bolt holes in 75S-T6 plain-scarf joints showed insignificant effect on fatigue life. Fatigue life of 75S-T6 for plain-scarf joints and double-shear joints was raised by giving them a preload halfway between yield and ultimate strength. Tests showed that penetrant inspection methods inside the bolt holes did not give reliable indication of fatigue cracks. Static tests of cracked double-shear joints for 75S-T6 and 24S-T4 showed ultimate loads lowered by 30 to 55%.

A. S. Andes, USA

1993. Hartman, A., and Jacobs, F. A., The effect of various fits on the fatigue strength of pin-hole joints, *Nat. LuchtLab. Amsterdam Rap.* M.1946, 27 pp., Apr. 1954.

The effect of a loose, an easy, a tight, and a hard drive fit on the fatigue strength at fluctuating tension (R about 0) of pin-hole joints, consisting of a steel pin with a diameter of 10 or 6 mm through 24S-T alclad sheet of 6 or 3-mm thickness, was investigated for endurances from 10^4 to 5.10^7 load reversals. It appears that a joint with a hard drive fit has a higher fatigue strength than a joint with a clearance fit or a tight fit. The effect of the fit of a pin-hole joint on the distortion of the hole at a static load was also determined. From authors' summary

1994. Welter, G., and Choquet, A., Fatigue tests of spot welds in Cor-Ten and mild steel, *Welding J.* **33,** 3, 134s-140s, Mar. 1954.

Fatigue tests and distribution of stresses in multiple Cor-Ten and mild-steel spot-welded sheets with and without hydrostatic treatment are described. From authors' summary

1995. Forrest, P. G., and Tapsell, H. J., Some experiments on the alternating stress fatigue of a mild steel and an aluminum alloy at elevated temperatures, *Proc. Instn. mech. Engrs.* 168, 29, 763–774, 1954.

Data are presented on the effect of testing frequency from 10 to 8000 cpm on the reversed bending and axial stress fatigue strength of mild steel and an aluminum alloy at room and elevated temperatures. The fatigue strength of mild steel was found to be primarily cycle-dependent at room temperature but at 400–500 C it was primarily time-dependent. Authors also extended earlier work on determination of difference between actual and nominal stress distribution in bending fatigue specimens by considering the nonlinearity in dynamic stress-strain properties. Bending and axial fatigue strengths were found to compare more favorably when stress redistributions were analyzed, the remaining differences between bending and axial strengths being attributed to the "stress-gradient" factor.

B. J. Lazan, USA

1996. Mann, J. Y., The effect of stress concentrations on the fatigue resistance of 24S-T aluminum alloy, *Aero. Res. Lab. Melbourne, Austral. Rep.* SM 217, 63 pp., Nov. 1953.

An extensive series of rotating cantilever fatigue tests is reported in which five different 45° vee notches having K_t values of 10, 5.5, 4.3, 2.5, and 1.5, respectively, were used to investigate the effects of stress concentrations upon the fatigue properties of 24S aluminum alloy.

Tests were made from a nominal stress of 85,000 psi to a stress corresponding to a fatigue life of 100×10^6 cycles. Static bend tests were also made on each type of notch.

Results show that the greatest strength reduction of the five notches investigated is caused not by the sharpest notch but by a notch of $K_t = 5.5$. The value of K_f for a particular notch is dependent on the fatigue life at which it is measured but appears to reach a maximum at between 10^6 and 10^7 cycles.

It was found that, for this alloy, K_t and K_f are related by the expression $K_f = K_t(1.09 - 0.09K_t)$. From this expression it follows that the maximum strength reduction ($K_f = 3.2$) will be caused by a notch of $K_t = 5.8$.

The complete S–N curve in bending appears to be a continuous curve of gradually decreasing negative slope which originates at the static ultimate strength in bending (corresponding to a "life" of 0.25 cycle) and approaches a line parallel to the cycle axis asymptotically.

The average fatigue lives of specimens tested at the same nominal stress were found to increase as the rate of cycling was increased. From author's summary

1997. Love, P. P., Forrester, P. G., and Burke, A. E., Functions of materials in bearing operation, *Proc. Instn. mech. Engrs. Auto. Div.* no. 2, 44 pp., 1953–1954.

Numerous factors affecting the operation of plain bearings, principally crankshaft, main, and pin bearings, are considered.

and the problems of bearing design, from the aspect of selection of the various materials which are combined in the construction of a bearing assembly, are discussed. An attempt is made to bring together conclusions reached by studying the factors referred to and the performance of bearings in practice. The latter is based on a study in summary of the three kinds of bearing failure, namely, seizure, excessive wear, and mechanical breakdown. Comment on recent work by Lunn and by Roach is made, and a working hypothesis on the effective fatigue strength of a bearing lining is proposed. From authors' summary

1998. **Watanabe, M., and Satoh, K., On the mechanism of annealing treatment for stress relief,** *Technol. Rep. Osaka Univ.* 4, 71–81, Mar. 1954.

The mechanism of annealing treatment for residual stress relief was studied from the viewpoint of theory of welding stress and creep and relaxation phenomena of the material. So-called "H-type" constrained specimen was annealed after welding and residual stresses before and after annealing treatment were compared. Theory of stress relief due to annealing treatment was developed by the use of the results of tensile creep tests, and theoretical values of relieved stress were compared with experimental ones. From authors' summary

1999. **Rinehart, J. S., Fracture during explosions** (in Swedish), *Tekn. Tidskr.* **85,** 11, 235–240, Mar. 1955.

Material Test Techniques

(See also Revs. 1975, 1989, 1991, 1992, 1994, 1995, 1996, 1997, 2011, 2016, 2017, 2018, 2171)

2000. **Schultze, W., and Schimmer, L., Correlation between micro and macrohardness** (in German), *Arch. Eisenhüttenw.* 25, 7/8, 337–339, July/Aug. 1954.

Microhardness numbers according to Vickers method obtained on test pieces of steels with macrohardness numbers from 250 to 850 units are studied. Test loads from 10 to 3000 grams were used. If the measured diagonal of the impression square is plotted on a double-logarithm paper against the actual test load, there are obtained very good linear correlations with quite small scatter bands. From these the Meyer exponents for different combinations of test loads and materials hardnesses are calculated. Thus, authors have found that the Meyer exponents are influenced only by the test material and that, within limits characteristic for different materials, the rate of test load has no perceptible influence. R. Nilson, Sweden

2001. **Stutterheim, N., Lochner, J. P. A., and Burger, J. F., A method for determining the dynamic Young's modulus of concrete specimens developed for corrosion studies,** *Mag. Concr. Res.* no. 16, 39–46, June 1954.

The effect of aggressive environments on concrete can conveniently be studied by observing the resultant changes in the dynamic modulus of elasticity of test specimens. An apparatus for rapid and accurate measurement of the fundamental transverse and longitudinal frequencies of a 1 × 1 × 11-in. concrete specimen is described. Typical experimental results are presented. From authors' summary

2002. **Krieger, R. J., Wenk, S. A., and McMaster, R. C., Nondestructive test methods for inspection of welded joints,** *Welding J.* **33,** 3, 154s–160s, Mar. 1954.

The nondestructive test methods applicable to flaw detection in welds in ship structures are radiography, magnetic particle, ultrasonics, and fluid penetrants. At present, radiography is the most extensively used. The magnetic-particle method has found considerable application, and fluid penetrants are used occasionally, while the ultrasonic method has not yet been used on ship structures.

Radiography, at present, is the most reliable and offers the best sensitivity to the detection of flaws in welds. The ultrasonic method offers a considerable potential and may prove more expedient than radiography if developed to provide the quality of inspection desired in welds in ship structures. The magnetic-particle method is established to the point where it serves as a useful inspection tool, particularly when used in conjunction with radiography. Further development may enhance its applicability.

Filmless techniques such as xeroradiography and fluoroscopy offer some potential, but both require further research and development before they may be applicable to this type of inspection. From authors' summary

2003. **Locati, L., Methods for testing certain rubber parts having mechanical functions on vehicles** (in Italian), *ATA* **6,** 5, 378–386, Feb. 1953.

Mechanical Properties of Specific Materials

(See also Revs. 1936, 1981, 1992, 1995, 1998)

2004. **Zaat, J. H., Hardness and plasticity of metals. Parts I, II** (in Dutch), *Metalen* **9,** 22, 23; 353–358, 373–380, Nov., Dec. 1954.

A survey of modern physical approach to hardness, especially in relation to the theory of plasticity. It is pointed out that hardness is not a fundamental parameter of the material but corresponds with one point of the metal's universal stress-strain relation. In theory, several hardness measurements with the same indentor, varying the load, should enable us to construct this relation, unless the indentations are of a similar form (in the latter case, all hardness values correspond to the same single universal stress-strain combination). Author shows which approximations have to be made to calculate the stress-strain behavior from hardness measurements in practice.

Reviewer is less optimistic about the probability that the hardness test will be developed in the future into a method of analogous value to the tensile test, bend tests, etc., without losing its advantage of simplicity. He thinks it gives a valuable approximation at most under limited circumstances; e.g., when the influence of a strongly limited number of production factors on an otherwise defined material has to be studied.

Another merit of the hardness test is its capacity to check consistency and reproducibility of metal. Author, from his point of view, is inclined to prefer methods for that purpose that give indentations of a form independent on the applied load. A table of the most frequently used types of hardness tests is added to this interesting paper. G. de Witte, Holland

2005. **Talbourdet, G. J., A progress report on the surface endurance limits of engineering materials,** First Ann. Conf. ASME-ASLE, Baltimore, Md., Aug. 1954. Pap. 54—Lub-14, 17 pp.

This progress report is a continuation of the roll tests started by Prof. E. Buckingham of The Massachusetts Institute of Technology in 1931, to determine the load-life characteristics of engineering materials subjected to rolling and combined rolling and sliding actions. For applications in design, the load-stress factors of several cast-iron and steel materials derived from the

tests are given not only for rolling-contact conditions but also for combined rolling and various per cent sliding actions.

From author's summary

2006. Anderson, W. J., and Nemeth, Z. N., Materials and designs of cages for high-speed cylindrical roller bearings, *Lubrication Engng.* **11,** 1, 40–45, Jan.-Feb. 1955.

In an investigation of four outer-race-riding cage-type bearings (two with leaded brass and two with nodular-iron cages), heavy wear was found to accompany cage slip. Nodular iron seemed to promote cage slip at DN values in excess of 1.2×10^6; consequently, bearings with leaded-brass cages showed less wear than did bearings with nodular-iron cages at very high speeds. Studies of four experimental and two conventional design roller bearings revealed that the experimental bearings operated at lower temperatures and to higher limiting DN values than did the conventional bearings. The experimental cages were designed with the idea in mind of offering less resistance to the flow of lubricant into and out of the interior recesses of the bearing.

From authors' summary

2007. Van Raamsdonk, G. W., Coating of metals with latex rubber (in Dutch), *Ingenieur* **67,** 2, C.1–C.7, Jan. 1955.

2008. Kozacka, J. S., Erickson, H. A., Highriter, H. W., and Gabriel, A. S., An investigation of cemented tungsten carbide as bearing material, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-3, 7 pp.

2009. Coates, B., Properties of light springs, *Metal Treatm.* **7,** 105, 284–288, June 1954.

2010. Hoyle, R., The thermal diffusivity of hardened cement paste, *Mag. Concr. Res.* no. 16, 33–36, June 1954.

The thermal diffusivity of hardened cement paste was measured by immersing long square bars in a steam atmosphere. Thermocouples were used to read temperature at the surface and on the axial center line during the period of unsteady state of temperature distribution. By reference to existing information for an infinitely long square bar, the thermal diffusivity of cement was calculated for each specimen.

From author's summary

2011. Tests of membrane-forming compounds for curing concrete, *Wwys. Exp. Sta. tech. Memo.* 6–385, 62 pp., June 1954.

Report reviews briefly the considerations involved in establishment of the testing procedures, their nature, and some of the precautions that must be observed in their performance.

From summary

2012. Sawaragi, Y., and Tokumaru, H., On the new model for the dynamical behaviour of the inelastic materials with hereditary characteristic, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 33–36.

Authors assert that fillers like carbon black cause nonlinearity in the dynamic stress-strain relations of rubber, even for small amplitudes. To describe such behavior, authors propose as model a nonlinear spring, a number of Voigt elements, and a number of Bingham elements (solids of fixed yield point, elasticity, and viscosity), all in series. Some general relations are given which hold for this model. There are no applications to real materials, nor a molecular interpretation of the model.

F. C. Roesler, England

2013. McGarry, F. J., Review of plastics developments in 1953–1954, *Mech. Engng., N. Y.* **77,** 4, 318–320, Apr. 1955.

2014. Christie, D. R., Reinforced plastics, *Engng. Digest* 1, 1, 16–17, Nov. 1954.

2015. Zandman, F., Study of the deformation and fracture of plastic materials (in French), *Publ. sci. tech. Min. Air, Paris* no. 291, 198 pp., 1954.

Viscoelastic behavior and fracture of Plexiglas (methyl methacrylate) are investigated. From tensile test, stress-strain and creep curves are determined for different loading rates, either continuous or not. Photoelasticity proves particularly apt as optical retardation is proportional to strain rather than to stress.

Kammerer's and l'Hermite's viscoelastic theories are related: experiments did not confirm constancy of limit elongation under a given stress for any loading procedure. In a disk subjected to uniform radial tension, strains were found to be intermediate between elastic values and those derived from Colonnetti's principle of least elastic and plastic work, together with Mohr's yield criterion.

Strained Plexiglas remains neuter to x rays.

Small superficial cracks may point out local stress concentrations.

Particular attention is given to the investigation of impact and fracture by means of photoelasticity coupled with ultrarapid movie camera; on the fracture's surface, smooth sources of failure (brittle fracture) are surrounded by rough zones whose characteristics (nature and orientation of ribs and hackles) are carefully described. Notches cause smooth brittle fracture and lower resistance up to 1/10.

Isochromatics in impact tests propagate with an oscillating diagram in which peaks can considerably surpass ultimate static strength. Interval between impact and fracture (minimum 1/2000 sec) was registered for different striking velocities. Rupture begins on tension side, propagates at a rate between 30 and 120 m/sec normally to beam axis up to a singular point at 2/3 of thickness, where crack triples.

Book offers a precious collection of experimental results; particularly interesting are those derived from ultrarapid registration.

Critical comparison with the related theories is, up to now, less developed.

D. Gentiloni-Silverj, Italy

2016. Rabinovitch, J., and Marcatand, J., Process of determination of elastic constants of glass (in French), *Rev. Opt. (theor. instrum.)* **34,** 2, 103–105, Feb. 1955.

2017. Meredith, R., Relaxation of stress in stretched cellulose fibres, *J. Text. Inst. Trans.* **45,** 6, 438–461, June 1954.

An apparatus is described for making stress-relaxation tests on yarns or monofils at controlled humidity and temperature.

From author's summary

2018. Lord, Joan, and Taylor, H. M., The bubble pressure test for the measurement of the pore size of fabrics. Part I—The development of the test, *J. Text. Inst. Trans.* **45,** 5, 371–379, May 1954.

An instrument has been designed, and a technique devised, for measuring the equivalent pore size of textile fabrics. The method is based on the determination of the pressure necessary to force air through the pores of a specimen of the fabric which has been completely wetted by a supernatant liquid of known surface tension. The effects of variations in certain arbitrary conditions have been investigated and a standard method of testing has been proposed.

From authors' summary

Mechanics of Forming and Cutting

(See also Revs. 2006, 2124, 2125)

2019. **Kronenberg, M., Principles of machining knowledge, Vol. I. Single point tools [Grundzüge der Zerspanungslehre. Bd. I: Einschneidige Zerspanung], 2nd enlarged and rev. ed.,** Berlin, Springer-Verlag, 1954, xxvi + 430 pp., 293 figs.

This textbook attempts to make a synthesis of the actual machining knowledge. It is divided into two parts: (1) Theoretical or physical knowledge, and (2) technical or applied knowledge. It includes many references, as well as different parameters of developed formulas, with equivalent German and American standards and with conversion data of metric and American units.

In the theoretical part (74 pp.), writer discusses the mechanics of chip formation, the influence of material cut, dimensional analysis of chip formation, heat in cutting of metals (with particular discussion of heat dissipation, lubrication, and cooling), and geometry of cutting edge and its influence on chip formation.

The technical or applied part (321 pp.) is divided into five chapters, discussing (1) cutting speed, (2) cutting forces and specific pressure, (3) required horse power, (4) mutual relations of particular machining parameters, and (5) many practical examples.

Appendix A (11 pp.) lists suggested values of formula constants, several practical examples, and both very common and those rather rare machining formulas. Appendix B (18 pp.) includes conversion tables (inch-millimeter), dimensional and physical units of metric and American measurement systems, as applied in machining, and a comparative survey of German DIN and American SAE steel standards.

The objective of the author to present a synthesis of machining knowledge, based on a very broad and general review of research and technical data available anywhere, has been fully realized. In his explanation of machining knowledge he tries to pass from the explanation of principles to shop application and to establish handy formulas. The reviewed textbook does not discuss all possible aspects of machining. The discussion of cutting fluids is rather short, and author's opinion that this subject does not yet have enough theoretical explanation might not be shared. A discussion of tool wear, of wear resistance, of carbide grades, and of chip breakers might also be included or enlarged. In any event, the book constitutes the largest source of very precious information, both for theoretical and practical use. It also constitutes a bridge unifying the machining experts of both sides of the Atlantic Ocean. It should be in every technical library and can serve all machine-tool builders, production engineers, and research men. A. Niedzwiedzki, USA

2020. **Isnardi, P. A., The index of chip-ability** (in Italian), *Ingegnere* **28,** 9, 1003–1007, Sept. 1954.

The mechanics of metal cutting as developed by Merchant and others is reviewed. Author then proceeds to derive certain relationships involving the cutting force components as well as the geometry of chip formation in a turning operation. He shows, for instance, that in knowing the rake and shear angles it is necessary to measure only the force component in the direction of tool motion. All other factors and forces can then be computed. Author also derives a relationship that enables him to determine the index of chip-ability, as he names it, without the use of a dynamometer. Merchant had called this important angular property the machining constant. In this determination the rake angle, shear angle, and chip orientation are the only measurements involved. These can be obtained from the tool geometry and a photomicrograph of the chip taken perpendicular to the cutting edge. Two simple chip-ability equations are given, one for the tool with a positive rake angle, the other for a negative rake angle. J. P. Vidosic, USA

2021. **Carro Cao, G., The cutting of metals** (in Italian), *Ingegnere* **28,** 9, 971–982, Sept. 1954.

Paper presents a review of the work performed in the field of metals cutting from Taylor's time through Merchant.

J. P. Vidosic, USA

2022. **Sykes, C., Internal stresses in some types of forging,** *N. E. Cst. Instn. Engrs. Ship. Trans.* **70,** part 2, 61–92, 1953–1954.

2023. **Salmon, P., and Carougeau, M., Metal working by grinding [Le travail des métaux par abrasion],** Paris, Société de Publications Mécaniques, 400 pp., 350 figs. 3000 Fr.

2024. **Keck, K. F., The greatest possible rounding for the crest of teeth for racklike gear cutting tools** (in German), *Werkstatt u. Betrieb* **87,** 10, 623–624, Oct. 1954.

A graphical and mathematical analysis of the geometrical relations between the profile and the rounding of the crest of the tooth for rack cutters with metric dimensions.

A. O. Schmidt, USA

2025. **Storchheim, S., How to understand cold working of metals,** *Amer. Machinist* **98,** 18, 101–108, Aug. 1954.

2026. **Sasaki, T., Ogura, T., and Kobayashi, A., Research on the "coolant through the wheel" in the grinding field** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **20,** 98, 643–647, 1954.

Data are presented showing the performance of the "coolant through the wheel" in the grinding field, which means a practice of supplying the coolant through the structure of the grinding wheel with the aid of centrifugal force developed by the wheel rotation and having the merit of cooling the grinding surface of work directly.

Experiments cover how the grinding forces are influenced by the amount of coolant, depth of cut or grade of grinding wheel in the cases of "coolant through the wheel" practice and ordinary practice.

In conclusion, authors show that "coolant through the wheel" practice prevents loading of the wheel and is more effective when the amount of coolant is small and the depth of cut is large.

From authors' summary

2027. **Digby, P. K., and Paul, W. J., Plastic tools for aircraft production,** *Coll. Aero. Cranfield Rep.* 87, 75 pp., Jan. 1955.

2028. **Turnbull, J. S., Development of the lost-wax process of precision casting, 1949–53,** *Instn. mech. Engrs. Auto. Div.*, 1–8, 1955.

2029. **Niedzwiedzki, A., How to select tool grades, feeds and speeds,** *Canad. Mach. Manufact. News*, pp. 164, 166, 168, Sept. 1954.

2030. **Leinweber, P., edited by (in co-operation with Berndt, G., and Kienzle, O.), Handbook of length measurements [Taschenbuch der Längenmesstechnik],** Berlin, Springer-Verlag, 1954, xxiii + 806 pp., 790 figs., 39 tables. DM 27.

The authors together with twenty other contributors have attempted to cover in one volume the entire field of inspection and measurement that one is likely to encounter in a machine shop. This includes a thorough survey of measuring fundamentals with unusually close attention paid to measuring errors. Measurement of simple parts and gages is discussed as well as more complicated problems concerning gears, splines, threads, bearings, and

machine tools. Most useful is the analysis of a large number of measuring instruments and machines, with optical devices receiving special attention. The authors have concentrated largely on German instruments, and nearly all the references listed are German publications. Statistical aspects of measuring errors and statistical quality control are also treated.

The book is recommended to all serious students of inspection methods and procedures. E. G. Loewen, USA

2031. Sims, R. B., and Slack, K. H., The roll-setting method of automatic control of gauge in hot and cold rolling mills, *Instn. mech. Engrs.*, 3–10, 2 plates, 1954.

A promising method to reduce and possibly eliminate off-gage scrap and to facilitate precision rolling in industry is described in detail, with some experimental results. The deviation Δh of a required finished thickness h' is given by $\Delta h = F/M + S_0 - h'$, where F is the roll load and M the elastic constant of the mill. S_0 indicates the roll setting, i.e., the linear displacement of the screws from the position in which the rolls just touch each other. The developed system measures F and S_0 simultaneously and builds up an electrical signal proportional with Δh, serving as error signal of a closed-loop regulator for gage control.

G. de Witte, Holland

2032. Hallendorff, H., Surface roughness: requirements and possibilities (in Swedish), *Tekn. Tidskr.* **83,** 35, 709–715, Sept. 1953.

Hydraulics; Cavitation; Transport

(See also Revs. 1904, 2050)

2033. Addison, H., A treatise on applied hydraulics, 4th rev. and enlarged ed., New York, John Wiley & Sons, Inc., 1954, vii + 724 pp. $9.50.

The fourth edition of Herbert Addison's work, which has been a little modified, is a very interesting book about the basic principles of hydraulics and especially the main practical applications of these theories.

The author mentions particularly the numerous experiments he has been performing in his laboratory during more than thirty years. Perfectly clear accounts are given, which lead to many industrial applications.

In addition we must mention an innovation of great value for engineers as well as for professors. The work concludes with several supplements: (a) exercises—217 in number—on every chapter of the book; (b) a table of conversion factors; (c) a key to symbols used in the book; (d) an important bibliography classified according to the chapters of the book, on the one hand, and by authors on the other hand.

In brief, this work will prove of high interest to those who will use it. L. Escande, France

2034. Press, H., Dams and water power plants. I. Storage dams [Stauanlagen und Wasserkraftwerke. I. Talsperren], Berlin, Wilhelm Ernst & Sohn, 1953, viii + 212 pp., 326 figs. DM 26.

After a brief introductory section containing general remarks about dams, the book is divided into two main sections dealing, respectively, with masonry and earth dams for barrage purposes. Chapters referring to masonry dams include analysis of the various structures, namely: gravity dams, arch and arch-gravity dams, shell and dome pattern dams, and, finally, buttress and multiple-arch dams. Many well-chosen illustrations show design and construction details.

Less concern is given to calculation methods, only the essentials of them being reported in the volume. As an example, for arch and shell dams, the book gives fundamentals on load-distribution methods after Ritter, Stucky, and the U. S. Bureau of Reclamation, and on step-by-step calculations for vaults with fixed abutments (Tölke), with simplifications allowed for the cylindrical taper. Very little emphasis is given to stress determination in buttress dams.

For spillway and pressure outlet works, besides the rich descriptive material, only a few hints are given to the hydraulic problem itself. The following section on earth dams is clearly written and very neatly illustrated. A selected bibliography (especially from German language literature) is given at the end of the volume. A. Ghetti, Italy

2035. Press, H., Dams and water power plants. II. River barrages [Stauanlagen und Wasserkraftwerke. II. Wehre], Berlin, Wilhelm Ernst & Sohn, 1954, viii + 204 pp., 326 figs. DM 30.

Unlike vol. I (see preceding review) the subject is here treated in greater detail, as is the static and hydraulic behavior of structures. General arguments appear in the first section, presenting hydraulic material from a rather conventional point of view. It seems to reviewer that author has given too much credit to reported formulas dealing with bed excavations downstream of weirs. In the following section, dealing with overflow barrages, the analysis of flow in permeable foundation soils for piping protection is not brought up to date with more recent literature. On the other hand, the chapter on siphon weirs is a very valuable contribution.

The last section of the book, dealing with the various types of gates, succeeds admirably in a thorough presentation of the matter, filling a gap in the technical literature. Reviewer regrets that in this, as well as in the preceding volume, too little space is devoted to intake works, a subject only superficially treated also in vol. III (see following review) dealing with water power plants. Selected bibliography, as in the first volume, is included.

A. Ghetti, Italy

2036. Press, H., Dams and water power plants. III. Water power plants (Stauanlagen und Wasserkraftwerke. III. Wasserkraftwerke), Berlin, Wilhelm Ernst & Sohn, 1954, vii + 340 pp., 356 figs. DM 35.

Two introductory chapters are devoted to general considerations and design fundamentals for hydroelectric power plants. In the next section, amply illustrating various types of development, emphasis is given to run-of-river plants, with turbines submerged or embodied in gate piers, and to underground stations with long discharging tunnels. A brief hint refers to tide energy plants.

The next section of the volume concerns conveyance works, such as canals, tunnels, and pipelines, regulating devices such as surge tanks, and power-house equipment. As in prior volumes (see preceding two reviews), due consideration is given to rich and attractive illustrative material and to clear and careful descriptions. It is reviewer's opinion that the design engineer does not always get from the book a clear approach for calculation. This is particularly true for the static behavior of penstocks and for water-hammer and stability problems in conveyance conduits and underground discharge canals. As in the two preceding volumes, a rich list of references is given, especially from German literature.

Professor Press' work should be regarded as very useful and helpful for practicing engineers, since it contains much unconventional material not easily found in books treating similar subjects. Except for some lack of completeness and disparity

of presentation, the three volumes form, on the whole, a most valuable contribution to technical literature on dams and water power plants. A. Ghetti, Italy

2037. Bohnet, W. J., and Stinson, L. S., Fanning friction factors for air flow at low absolute pressure in cylindrical pipes, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-16, 11 pp.

Authors refer to about nine series of measures of pressure drops in four long manifold pipes, where air was flowing at very low pressures (0.05 to 1 mm Hg). Nominal diameters of the pipes tested were 18, 12, 8, 6 in. The Reynolds numbers R_D obtained were small (in every case $R_D < 1150$). Because pressure drops are large, values of friction factor f are calculated with Fanning formula for flow of compressible fluids in pipes.

Authors plot f against the corresponding R_D. For a same R_D, the f values vary and generally are 50 to 100% larger than those given by Hagen-Poiseuille law. Authors believe that presence of branches in manifold pipes tested is probable cause of only slightly higher pressure drops than in pipe of continuous wall. Errors in pressure measurement were kept below 10%.

Reviewer points out that spread in f values is larger at smaller pressures and that values of R_D were calculated assuming viscosity coefficient as unchanging, also at very low pressures.

M. Viparelli, Italy

2038. Maitre, R., and Obolensky, S., Study of some flow characteristics in the downstream part of spillways (in French), *Houille blanche* **9**, 4, 481–510, July-Aug. 1954.

2039. Barats, L. A., and Aleksandrov, V. V., General method of critical depth determination in channels of various form (in Russian), *Gidrotekh. i Melior.* no. 7, 58–62, July 1954.

Assumed dimensionless numbers are introduced into general formula for critical depth and adapted to trapezoidal, circular, and other closed sections. S. Kolupaila, USA

2040. Abaliants, S. Kh., Transport capacity of open uniform stream (in Russian), *Gidrotekh. i Melior.* no. 7, 35–44, July 1954.

A formula for nonsilting channels is suggested: $\rho u = kv^3/R^{3/4}$, where ρ is volumetric concentration of suspensions, u mean hydraulic size of particles, v velocity, R hydraulic radius, k const, in metric units equal to 26. S. Kolupaila, USA

2041. Hunt, J. N., The turbulent transport of suspended sediment in open channels, *Proc. roy. Soc. Lond.* (*A*) **224**, 1158, 322–335, July 1954.

Using the theory of turbulent diffusion with some new assumptions, author derives a new equation for the vertical distribution of suspended sediment. He takes account of the volume occupied by the sediment, and assumes that the velocity distributions for the fluid and the sediment are different, both being generalized von Kármán equations. The diffusion coefficient for sediment is calculated from the sediment velocity profile by analogy with the Boussinesq formula defining eddy viscosity.

Author's equation fits Vanoni's experimental data better than the conventional suspended-load equation, but it is considerably more complex and involves an additional arbitrary constant.

Reviewer believes author's equation does not, at present, have much advantage over the simpler suspended-load equation because several major problems in field application have not yet been solved; e.g., unknown boundary condition for sediment concentration, nonuniformity of particle size, hindered settling, ripple formation in bed, and difficulty in accurately determining the bed shear. N. H. Brooks, USA

2042. Obrazovskiĭ, A. S., Computation of conjugated depths in jump emerging at trapezoidal annihilators (in Russian), *Gidrotekh. Stroit.* **23**, 5, 30–33, May 1954.

A formula is developed involving the top width of trapezoidal floor baffles or sill and their side slope. Formula is more complicated than the classical one for perfect jump. Construction of an end sill can substitute a stilling pool.

S. Kolupaila, USA

2043. Bashkirova, L. S., Determination of conjugated depths in a parabolic channel (in Russian), *Gidrotekh. i Melior.* no. 4, 51–54, Apr. 1954.

An equation is derived in terms of $h/Q^{1/2}$ and a nomogram given for computations. S. Kolupaila, USA

2044. Sapozhnikov, M. M., Velocity and discharge measurement in penstocks (in Russian), *Gidrotekh. Stroit.* **23**, 1, 41–43, Jan. 1954.

A pitot tube in the form of a rod is introduced into a penstock and its orifices are located in the center point of the pipe. Difference in pressure, read on differential manometer, gives maximum velocity. A constant ratio is used to compute the average velocity. This ratio varies with the size of pipe; for old cast-iron pipes it is 0.77 for 4-in. pipe to 0.84 for 52-in. pipe. The discharge thus computed is supposed to be exact to 2%.

S. Kolupaila, USA

2045. Hellström, B., and Rundgren, L., Model tests on Ölands Södra Grund Lighthouse, *Acta Polyt.* **146**; *Civ. Engng. & Bldg. Cons. Ser.* **2**, 6, 64 pp., 1954.

See AMR **7**, Rev. 3253.

2046. Blaisdell, F. W., Equation of the free-falling nappe, *Proc. Amer. Soc. civ. Engrs.* **80**, Separ. no. 482, 16 pp., Aug. 1954.

A general equation for the form of the nappe is developed. The equation is not valid close to the crest, but applies to that portion of the nappe that is free-falling—where pressures within the nappe are atmospheric. The constants in the equation have been evaluated for the vertical, sharp-crested weir having approach channel depths ranging from deep to zero (the free overfall); that is, over the entire range of subcritical approach velocities. The evaluation is made using nappe coordinates obtained by others. The equation is checked by comparing its predictions with a number of published profiles. The comparison is shown to be excellent for the lower approach velocities and good at the higher approach velocities. From author's summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 1989, 2037, 2041, 2084, 2087, 2150, 2163, 2190)

2047. Roshko, A., On the wake and drag of bluff bodies, *J. aero. Sci.* **22**, 2, 124–132, Feb. 1955.

The basic assumption in Kirchhoff's method is that the pressure everywhere in the wake behind a bluff body (and therefore also on the base of this body) is the free-stream pressure p_∞. Because this method yields a lower drag of the body than observed, author introduces the parameter $k = (1 - C_{ps})^{1/2}$ which allows arbitrary base pressure and which must depend on the dynamics of the wake. For a cylinder of given cross-sectional shape, the drag C_D and the wake width d' are functions of k only. These functions are used to relate C_D and the Strouhal number $S = nd/U$ (n vortex shedding frequency, d cylinder diameter) to the wake Strouhal number, $S^* = nd'/U_S$. It is found that $S^* = 0.16$ for all cylinders. In another approach, k is evaluated by using von Kármán's solution for the vortex street. Although

there is actually only little known of the processes in the wake immediately downstream of the cylinder, especially of the vortex formation, this theory reduces the empiricism to a minimum.

F. Berner, USA

2048. Cheng, H. K., and Rott, N., Generalizations of the inversion formula of thin airfoil theory, *J. rational Mech. Analysis* **3,** 3, 357–382, May 1954.

Most of paper is concerned with determination of functions of a complex variable whose real and imaginary parts are given alternately on successive segments of the real axis in complex plane, and which satisfy certain conditions at infinity and may bave prescribed singularities at given points. This is practically equivalent to solving singular integral equation of thin airfoil theory for tandem "multi-planes" of prescribed form. Solutions of homogeneous integral equation are used extensively in treatment of various special cases which increase in complexity through the paper.

Paper concludes with outline of a method for solving a more general problem in which different linear combinations of real and imaginary parts of required function are specified on successive segments of real axis. G. N. Ward, England

2049. Laidlaw, W. R., and Hsu, P. T., A semiempirical method for determining delta-wing pressure distributions in an incompressible flow, *J. aero. Sci.* **21,** 12, 854–856, Dec. 1954.

Note in Readers' Forum.

2050. Tan, H. S., On motion of submerged cylinder, *J. aero. Sci.* **21,** 12, 848–849, Dec. 1954.

Note in Readers' Forum.

2051. Lessen, M., Note on the propagation of infinitesimal disturbances in gases according to the Navier-Stokes equations, *J. aero. Sci.* **21,** 12, 849–850, Dec. 1954.

Note in Readers' Forum.

2052. Stewartson, K., On the free motion of an ellipsoid in a rotating fluid, *Quart. J. Mech. appl. Math.* **7,** part 2, 231–246, June 1954.

It is shown theoretically that, if a spheroid of density $\rho\sigma$ is placed symmetrically on the axis of a rotating fluid of density ρ, it will be in stable equilibrium for translational disturbances if $\sigma \leq 1$, and for rotational disturbances if $\sigma \geq 1$ in the case when it is oblate, or if $\sigma \leq 1$ in the case when it is prolate. Further, if $1 > \sigma > 1/9$, it will have a single period of translational oscillation, while if $\sigma < 1/9$ it will have two such free rotational periods; and if stable, it may have also a free period of rotational oscillation. Some experiments on the free motion of bodies in rotating fluids are also described. These are in substantial agreement with the theoretical predictions. It was also observed that there are asymmetric positions of equilibrium, stable with respect to angular displacements, having the axes of the bodies horizontal.

From author's summary by G. V. R. Rao, USA

2053. Gol'din, E. M., Motion of viscous fluids in the interplate space of a separator (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15,** 137–146, 1953.

Chemical and food industries utilize to a great extent the method of mixture separation by centrifugal force acting on the fluid with the aid of interplates. The viscous fluid in a separator moves in a thin layer under a centrifugal force. Utilizing the smallness of the gap of the interplates, we can assume velocity components of the fluid as polynomials of the second degree in a quantity relating to the gap. The external forces consist of centrifugal and Coriolis forces and can be expressed as functions of angular velocity of the axis of the separator, and velocity components of the fluid. On upper and lower interplates all velocity components must be zero. Hence the first terms in the above polynomials vanish. Substituting them into the equations of continuity and motion, we can find velocity components.

If Q be the capacity of separator, mean values of velocity components in radial and longitudinal direction v_ρ^0, v_φ^0 are given by

$$v_\rho^0 = Q/(2\pi\sin\alpha_0 h\rho);\ v_\varphi^0 = -Q/(12\pi\nu\rho)$$

where h is the width of slit, ν kinematic coefficient of viscosity, and α_0 the inclination of lower inter-plate to the axis of separator.

An example for a milk separator is given and proper values are obtained. M. Kataoka, Japan

2054. Taylor, E. H., and Harmon, D. B., Jr., Measuring drop sizes in sprays, *Indust. Engng. Chem.* **46,** 7, 1455–1457, 3 figs., 4 refs., July 1954.

A modification of the frozen drop method (as previously used by Longwell) is described, and preliminary results using water as the sprayed fluid are given. The spray is caught in a container filled with catching liquid—in this case hexane—kept at a low temperature, in this case minus 20 C, by means of dry ice. The container is fitted with a horizontal shutter located at a certain distance below the surface of the catching liquid, and with a catching pan located near the bottom of the container but suspended on the arm of a weighing balance. In operation the spray is directed upward, and in descending, lands first on the surface of the catching liquid and rapidly freezes, then settles on the horizontal shutter. After spraying, the frozen globules accumulated on the shutter are suddenly released and are allowed to fall on the submerged catching pan, and can be weighed by the balance. Because the fall proceeds according to Stokes' law, the weight-vs-time curve can be interpreted in terms of proportional weight of drops having certain size.

The differential density was 0.115 gram/gram H_2O; the range of Reynolds number was from 1 to 25; the depth of fall 12 inches. For these conditions the times of fall would range from about 4 minutes for drops of 100 microns to about 27 hours for drops of 5 microns diam. Method is comparatively rapid and requires no special sampling of spray. The theoretical and experimental test results showed reasonable agreement.

K. J. De Juhasz, Germany

Compressible Flow, Gas Dynamics

(See also Revs. 2051, 2076, 2094, 2104, 2107, 2111)

2055. Parkus, H., Sudden start of a Laval nozzle with an extended inlet tube (in German), *Öst. Ing.-Arch.* **8,** 2/3, 185–189, 1954.

Paper discusses transient temperatures, pressures, and nozzle thrust developed by a Laval nozzle connected suddenly to a combustion chamber by means of an extension tube. Solving the differential and energy equations for heat transfer from the gas with the Laplace transform, both tube wall and gas temperatures are determined as functions of time and distance along the tube. The use of heat-transfer coefficients based on *NACA Rep.* 1020 (1951) is suggested.

Since velocity transients are small compared to spatial velocity variations along the tube and in the nozzle, quasi-steady flow with perfect gas behavior is assumed. The nozzle thrust may be evaluated directly in terms of the transient temperatures at the nozzle inlet (= tube exit). To determine the instantaneous combustion chamber pressure, an iterative procedure along the tube

will be necessary, assuming critical flow at the nozzle throat. This iteration depends on the simultaneous solution of a Mach number expression in terms of local tube temperatures and pressures, and of the influence coefficient equation between pressure drop, Mach number, and friction coefficient.

No sample calculations are presented in the paper. Reviewer feels that numerical answers for selected cases and comparison of these results with values obtained by simpler analyses would greatly help to establish the practical applicability of the material presented. F. Landis, USA

2056. Ford, C. A., and Glass, I. I., An experimental study of shockwave refraction, *Univ. Toronto Inst. Aerophys. Rep.* 29, 66 pp., Sept. 1954.

This is one of a series of UTIA reports on the interaction of plane waves in a shock tube. Refraction at normal incidence at an interface between two different gases always produces a transmitted shock but may result in a reflected shock or rarefaction depending on a modified acoustical impedance of the two gases. Experimental data on the wave velocities were obtained using a wave-speed drum camera and schlieren system. Authors report good agreement with theory for a wide variety of shock strengths in case of He-air interfaces. Two methods were to reflect incident shock in air back into helium "cold front" or to draw out a slide separating air and helium just before shock arrived. Readers interested in quantitative experiments on refraction at any angle of incidence are referred to papers by Stoner et al., "Experimental observations of the interaction of shock waves at boundaries of various gases" [*Penn. State Coll. TR*, Feb. 1953] and R. Jahn, "Refraction of shock waves" [*Princeton Univ. Dept. Physics, TR* II-16, 1954]. W. Griffith, USA

2057. Boyer, E. D., Shock-wave yaw for 9 1/2° semiapex cone, *J. aero. Sci.* 21, 12, 856–857, Dec. 1954.

Note in Readers' Forum.

2058. Hida, K., On the curved shock wave due to an infinite wedge placed in a supersonic uniform flow, *J. phys. Soc. Japan* 9, 5, 853–860, Sept./Oct. 1954.

By approximate hodograph method, author claims to have found two new solutions for an infinite wedge whose angle is below the maximum deflection by the shock. Of these solutions, one corresponds to a subsonic flow behind detached shock and the other corresponds to a subsonic flow behind a curved attached shock. Although these solutions may satisfy the mathematical requirement set up by the author, they must be viewed with doubts on physical grounds. Y. H. Kuo, USA

2059. Rudinger, G., On the reflection of shock waves from an open end of a duct (Abstract), *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto*, 194–195, Feb. 1954.

2060. Imai, I., Application of the M^2-expansion method to the subsonic flow of a compressible fluid past a parabolic cylinder, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 349–352.

Author treats flow past a parabolic cylinder by his complex variable method [see *Proc. Phys.-Math. Soc. Japan* 24, p. 120, 1942] of dealing with the Poisson equations arising in the Janzen-Rayleigh method for two-dimensional subsonic flow. The coefficients of M^2 and M^4 in the expansion of the local velocity are the main results of the paper. No comparison with experiment is given, nor is the convergence of the process discussed.

L. C. Woods, Australia

2061. Simasaki, T., Application of Poggi's method to the calculation of complex velocity potential for compressible fluid flow, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 343–347.

Poggi's method is extended by making use of Imai's complex variable technique (see previous review). The subsonic flow about a circular cylinder is calculated as an example of the method.

Reviewer believes the method to be of little value for airfoil calculations. L. C. Woods, Australia

2062. Behrbohm, H., Airfoil theory in the sonic and supersonic region (in German), *Z. Flugwiss.* 1, 3, 62–77, Aug. 1953.

2063. Basch, A., Differential geometry of two-dimensional flow of gases (in German), *ZAMM* 34, 8/9, 332–334, Aug./Sept. 1954.

At each point of a steady flow a geometric relation is derived connecting the curvatures of stream and potential lines and the gradient of fluid speed. C. M. Ablow, USA

2064. Fell, J., and Leslie, D. C. M., Second-order methods in inviscid supersonic theory, *J. aero. Sci.* 21, 12, 851–852, Dec. 1954.

Note in Readers' Forum.

2065. Frost, R. C., Supersonic flap lift effectiveness for some general plan forms, *J. aero. Sci.* 21, 9, 609–614, 620, Sept. 1954.

Author finds that the calculation of this quantity is much easier if reverse-flow concepts are applied; in this way complicated corrections for edge effects are avoided. Both subsonic and supersonic trailing edges are considered and good agreement with experiment can be obtained when a correction is made for the profile angle at the trailing edge.

Maurice Holt, England

2066. Oswatitsch, K., and Sjödin, L., Axial supersonic flow around circular cones (in German), *Öst. Ing.-Arch.* 8, 4, 284–292, 1954.

Transonic and slender body approximations are used to compute the supersonic conical field over circular cones. Results are transferred to cones of arbitrary cross section by means of an equivalence theorem of Oswatitsch (not derived in this paper.)

H. Yoshihara, USA

2067. Kawamura, R., and Tsien, F., Internal supersonic flow in a circular cylinder, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; nat. Committee for Theor. appl. Mech., May 1953, 259–262.

The internal flow at zero yaw in an axially symmetric circular cylinder is determined by linear supersonic theory. Sources are distributed over the surface of the cylindrical duct and the velocity potential, velocities, and pressure coefficients computed in a manner similar to that used by Ludloff and Reiche [AMR 3, Rev. 316]. L. H. Schindel, USA

2068. Chester, W., Unsteady compressible flow in ducts, *Quart. J. Mech. appl. Math.* 7, part 2, 247–256, June 1954.

Let a one-dimensional rarefaction wave be produced in a channel by impulsive retraction of a piston at the escape speed of the fluid. Suppose that along a finite length (transition section) of the channel there is a slight variation of width. To determine effects of this deformation, author adds to the velocity potential of the rarefaction wave a perturbation potential $\varphi(x, y, t)$, where the x-axis (y-axis) is parallel (normal) to the axis of the channel,

and linearizes the partial differential equation satisfied by φ. By operational methods φ is expressed as a Fourier cosine series in terms of the variable y. Consideration of the first term of the series suggests that beyond the transition section the perturbation velocity at a point moving with the wave tends to decrease the flow velocity by an amount inversely proportional to time, while at a fixed point in the channel the perturbation velocity increases linearly with time. In the transition section disturbances accumulate and tend to increase the flow velocity if there is a throat, eventually producing a sonic regime. On this basis an attempt is made to describe the establishment of steady subsonic-supersonic flow in a converging-diverging nozzle.

J. H. Giese, USA

Wave Motion in Fluids

(See also Rev. 2192)

2069. Womersley, J. R., Oscillatory motion of a viscous liquid in a thin-walled elastic tube—I: The linear approximation for long waves, *Phil. Mag.* (7) **46,** 373, 199–221, Feb. 1955.

Author presents an analysis for the propagation of pressure waves in liquid-filled elastic tubes. The characteristic equation for the wave velocity is determined, and curves for wave velocity and damping as a function of a dimensionless ratio involving the kinematic viscosity of the liquid, the radius of the tube, and the frequency are plotted for various values of the Poisson ratio of the tube material. The motion of the liquid itself is studied. A perturbation method is introduced, designed to improve the linearized boundary conditions used in the original analysis.

Reviewer notes that a similar analysis leading to the wave velocity and damping, including analytical results for two ranges of the afore-mentioned dimensionless parameter, have been given by Morgan and Kiely [AMR **8,** Rev. 1718].

Since the original analysis is linearized, reviewer questions the meaning of the perturbation scheme to correct the boundary conditions without including the nonlinear inertia terms in the Navier-Stokes equations which contribute an equally important correction.

G. W. Morgan, USA

2070. Lehman, R. S., Developments in the neighborhood of the beach of surface waves over an inclined bottom, *Comm. pure appl. Math.* **7,** 3, 393–439, Aug. 1954.

Author treats the linearized two-dimensional potential problem of surface waves over an inclined bottom of uniform slope $\pi\alpha$. Asymptotic expansions valid near the origin are obtained as triple power series in z, $z^{1/\alpha}$, and log z, which reduce to double series when α is irrational; the radius of convergence of the expansion depends on the arithmetical character of α. Author then constructs an infinite set of solutions in terms of which every solution can be expanded and which is continuous in α.

This work is of considerable mathematical interest; it has no immediate engineering application to real waves on a sloping beach where linearization is inappropriate.

F. Ursell, England

Turbulence, Boundary Layer, etc.

(See also Revs. 1891, 2139, 2140, 2141, 2150, 2165, 2175)

2071. Mager, A., Three-dimensional laminar boundary layer with small cross-flow, *J. aero. Sci.* **21,** 12, 835–845, Dec. 1954.

Three-dimensional laminar boundary-layer flow over flat and over sharply curved surfaces is treated for flows in which the flow outside the boundary layer consists of a main component and a small crosswise component. For this type of flow a small perturbation method is used to solve the boundary-layer equations that are derived for an incompressible steady flow moving relative to a coordinate system which rotates with a uniform angular velocity. The effect on the velocity profiles of pressure gradient in the main flow direction and in the cross flow direction is calculated and discussed. The effect on the principal flow of crosswise variation of the cross flow and of rotation is also calculated.

The flow equations for the boundary-layer flow over a sharply curved surface are solved and the velocity perturbation caused by the wall curvature is obtained for both the principal direction and the crosswise direction.

The effect of compressibility is obtained by using Howarth's transformation. Examples are given to illustrate the flows on the casing and in the blade fillets of turbomachinery. One of the conclusions is that the crosswise variation of the flow has an important effect on separation.

N. Tetervin, USA

2072. Sandborn, V. A., and Slogar, R. J., Study of the momentum distribution of turbulent boundary layers in adverse pressure gradients, *NACA TN* 3264, 79 pp., Jan. 1955.

Evaluation and analysis are made of the mean and turbulent terms of the equations of motion and the stress tensor at four stations in a turbulent boundary layer with a progressively increasing adverse pressure gradient.

Good agreement between the values of skin friction obtained by heat-transfer skin-friction instrument measurements and by the evaluation of the Ludwieg-Tillmann empirical equation are found to exist. The evaluation of skin friction from the integrated momentum equation failed to agree with the results of other methods of obtaining skin friction.

From authors' summary by M. S. Uberoi, USA

2073. Davies, D. R., The problem of diffusion into a turbulent boundary layer from a plane area source, bounded by two straight perpendicular edges, *Quart. J. Mech. appl. Math.* **7,** part 4, 468–471, Dec. 1954.

Author determines a function $F(x, y, z)$ such that: (1) F satisfies the head conduction equation with allowance for convection in the x direction; (2) the wind strength is proportional to z^m $(m > 0)$; (3) the only nonzero components of the tensor diffusivity are K_{yy} and K_{zz}; (4) K_{yy} is proportional to z^m and K_{zz} to z^{1-m}; (5) F is held at a constant uniform value over the quadrant $z = 0$, $x > 0$, $y < 0$; (6) $\partial F/\partial z = 0$ over the other three quadrants of the plane $z = 0$.

G. K. Batchelor, England

2074. Truckenbrodt, E., An integral method for the calculation of the boundary layer on a rotating body of revolution in a uniform flow (in German), *Ing.-Arch.* **22,** 1, 21–35, 1954.

A solution of the momentum integral equations in the meridional and azimuthal planes is obtained for a rotating body of revolution at zero incidence in a uniform flow. On the assumption that (a) the ratio of circumferential to the longitudinal wall shear stress is proportional to the ratio of the corresponding velocity components and (b) similar velocity distributions, it is shown that the two momentum equations are independent. A "power law" relation for the wall shear stress is used to determine the momentum thicknesses from integral relations involving the variation of the streamwise velocity component and body radius with distance from the body nose. The circumferential wall shear stress is integrated to obtain the frictional torque. Approximate calculations are made of the position of the separation point and its variation with rotational speed.

Calculations are included for both laminar and turbulent boundary layers on a rotating disk, sphere, ellipsoid, and a semi-infinite body. It is noted that the frictional torque is approximately proportional to the circumferential speed.

G. M. Lilley, England

2075. **Batchelor, G. K., The skin friction on infinite cylinders moving parallel to their length,** *Quart. J. Mech. appl. Math.* 7, part 2, 179–192, June 1954.

The skin friction is calculated for an infinite cylinder moving steadily parallel to its length through a viscous fluid which is initially at rest.

At the start of the motion, the boundary layer is infinitesimal. Approximation of the governing equation of the impulsive motion gives the same skin-friction coefficients for cylinder of different cross sections. Second approximation introduces a small variation (25% at most) due to the cross-section shape. For section of same peripheral length the skin-friction coefficient decreases from a circular cylinder to that of a cornered cylinder onto the flat plate. Comparison is made with the exact solution of circular cylinders which is readily available from heat-flow studies. For a long time after the start of the motion, the problem is reduced to a potential one which is known for a few cross-section shapes. Solutions for intermediate time are not obtained and interpolations between the two previous cases are expected.

N. Van Le, USA

2076. **Korst, H., Solution of a free jet with allowance for initial boundary layer flow** (in German), *Öst. Ing.-Arch.* 8, 2/3, 152–157, 1954.

The equation of motion for a turbulent jet, with an effective eddy viscosity coefficient ϵ, is linearized and converted to a dimensionless form, use being made of an assumed relation of fairly general character between ϵ and the streamwise distance x. A further transformation results in an equation identical in form with the heat-conduction equation from which a uniparametric set of solutions is obtained. These require the momentum equation to relate them to the development of a free jet in space for given initial boundary-layer conditions. A comparison with experimental results due to Chapman provides an acceptable form for the $\epsilon \sim x$ relation. It is claimed that the solution is applicable to compressible flow with the Prandtl number unity.

A. D. Young, England

2077. **Chow, T.-S., On the average second moment of the energy spectral intensity,** *Quart. appl. Math.* 12, 3, 287–294, Oct. 1954.

After displaying the well-known equations governing the inertial interaction between sets of three Fourier coefficients of the velocity distribution in the homogeneous turbulent motion of a viscous incompressible fluid, author establishes lower and upper bounds to the mean-square velocity and vorticity, respectively, in terms of the initial values of these quantities. These bounds vanish and diverge, respectively, after a finite time (which vanishes with the viscosity), thus limiting their utility.

I. Proudman, England

2078. **Szablewski, W., Turbulent flow in divergent channels** (in German), *Ing.-Arch.* 22, 4, 268–281, 1954.

Turbulent flow in a plane diffusor with a large pressure gradient (0–4 deg half-angle α) is treated by extending Prandtl's mixing length l to include a second-degree dependence on the (non-dimensional) distance from the wall, η. The additional coefficient is evaluated from Nikuradse's diffusor data and is observed to be independent of the pressure gradient. Also incorporated is the variation in shear stress: the first refinement is linear in η to include the longitudinal pressure gradient, and the second refinement includes a first approximation of the inertia terms. The pressure gradient, wall shear stress, and velocity distribution are computed and the agreement with Nikuradse's data is good, at least to $\alpha = 3$ deg, and considerably better than for the logarithmic law away from the wall. The result is applicable to other Reynolds numbers and may therefore be of use in engineering problems.

J. R. Ruetenik, USA

2079. **Davies, D. R., On the problem of diffusion from an instantaneous point source released at ground level into a turbulent atmosphere,** *Quart. J. Mech. appl. Math.* 7, part 4, 462–467, Dec. 1954.

Author determines a function $F(x, y, z, t)$ such that (1) F satisfies the heat conduction equation with a tensor diffusivity whose diagonal components are proportional to t^α and whose non-diagonal components are zero, and (2) $t = 0$, F is infinite at $x = y = z = 0$ and zero elsewhere, the volume integral of F being finite. With various assumptions the author interprets F as the mean intensity of a diffusable quantity due to an instantaneous source in a turbulent atmosphere.

G. K. Batchelor, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 1918, 2047, 2048, 2062, 2065, 2094, 2095, 2096, 2097)

2080. **Liepmann, H. W., Extension of the statistical approach to buffeting and gust response of wings of finite span,** *J. aero. Sci.* 22, 3, 197–200, Mar. 1955.

See AMR 8, Rev. 1114.

2081. **Miele, A., Steady properly-banked turns of turbojet-propelled airplanes** (translation from *Riv. Aeronautica* 27, 1, 1951), *NACA TM* 1382. 33 pp., Mar. 1955.

See AMR 4, Rev. 4254.

2082. **McKinney, M. O., Tosti, L. P., and Davenport, E. E., Dynamic stability and control characteristics of a cascade-wing vertically rising airplane model in take-offs, landings, and hovering flight,** *NACA TN* 3198, 45 pp., June 1954.

An investigation has been made to determine the stability and control characteristics of a cascade vertically rising airplane model in the take-off, landing, and hovering phases of flight. The model had four propellers with the shaft axes essentially parallel to the fuselage axis and distributed along the span so that the four wings, which were arranged in cascade relation to turn the slipstream downward approximately 90°, were completely immersed in the slipstream of the propellers.

From authors' summary

2083. **Kondo, K., On the dynamics of the aeroplane and non-Riemannian geometry. Parts I, II,** *J. Japan Soc. aero. Engng.* 2, 7/8, 161–166, 193–196, July/Aug. 1954.

In the study of small oscillation of dynamical systems it is customary to take a small change Δx^α in the variables x^α, leading to a set of equations that possess no invariant properties. Consequently the resultant equations cannot be given a physical interpretation, nor can they be represented by a geometrical or electrical model. The equations can be used only to supply a numerical answer. It was shown by Synge that the equations of small oscillation of simple dynamical systems assume an invariant form (the path of a particle moving in an n-dimensional Riemannian space) if the mathematical changes Δx^α are replaced

by absolute (or covariant) changes δx^a. Such a tensorial study is undertaken in the present paper for the deviation of an airplane from steady rectilinear flight. Time is considered as an additional variable.

However, in the motion of an airplane two types of forces play a significant role, namely, the mechanical and aerodynamical forces, and it has long been known that there is not enough room within the framework of a Riemannian space to represent the interactions of two types of forces. The first appearance, as well as the first physical application of a non-Riemannian space, appeared in connection with the Unified Field Theories of Einstein and of his followers, in which electromagnetic and gravitational forces play simultaneous roles. The same tensors and spaces were utilized also by Kron for the acceleration as well as for the small oscillation studies of rotating electrical machinery in which both electromagnetic and mechanical forces coexist. It was to be expected that the present paper should also put to use the apparatus of non-Riemannian geometry. It is pointed out by Professor Kondo that the same set of tensor equations should apply also to the motion of a ship acted upon by hydrodynamic forces.

The use of an unaccustomed set of concepts should not scare the reader, however. In electrical machinery every strange geometrical motion corresponds to an easily visualizable physical concept. For instance, the Riemann-Christoffel curvature tensor corresponds to a spring effect and supplies a single over-all numerical measure for representing the steady-state stability of the entire system.

The present paper discusses only briefly the dynamical and aerodynamical meaning of each of the geometrical quantities. It works out in detail one special case by assuming a rectangular reference frame with origin fixed at the center of gravity of the airplane. The results are then compared with those given by conventional methods.

The dynamically more representative tensors of non-Riemannian spaces have led already to new inventions in the field of electrical machinery (like canceling the transient reactance of synchronous machines and generating extra stability power for the entire system). These truly scientific notions cannot help but supply similar aids in other and more complex dynamical systems also to insure greater steady-state and transient stability.

G. Kron, USA

2084. Cheng, H. K., A supplementary note on the spanwise loadings over slender airfoils, *J. aero. Sci.* **21, 12, 853–854, Dec. 1954.**

Note in Readers' Forum.

2085. Mollø-Christensen, E., and Ashley, H., Applicability of piston theory to the flow around wings in unsteady motion, *J. aero. Sci.* **21, 11, 779–781, Nov. 1954.**

In this note it is shown that certain simplification of the problem of finding the pressures on oscillating wings can be deduced directly from small disturbance considerations, and criteria for the applicability of the simplified theory can be obtained in the process. The general expression for the pressures on an oscillating wing is developed and the results of sample calculations are compared to results of more exact theory.

From authors' summary

2086. Walsh, J., Zartarian, G., and Voss, H. M., Generalized aerodynamic forces on the delta wing with supersonic leading edges, *J. aero. Sci.* **21, 11, 739–748, Nov. 1954.**

The virtual work (generalized force) done on a thin wing by a virtual displacement of a generalized coordinate supposed to be due to aerodynamic forces, i.e., an expression of the form

$$Q_{ij} = c^2 \int\int_{(A)} \Delta p_i(x, y) f_j(x, y)\, dx\, dy \qquad [1]$$

is studied (Δp_i resulting local pressure due to the deflection mode $f_i(x, y)$, c wing chord, $f_j(x, y)$ that deflection mode for which the virtual work is to be determined). Such expressions are met not only in the theory of elastic deformations but also in flutter analyses if the total vertical displacement of the wing is represented by the sum of the single displacements corresponding to the flutter modes $g_i(x, y, t)$ of the existing degrees of freedom, setting $g_i(x, y, t) = q_i(t) f_i(x, y)$ (x, y nondimensional coordinates in chordwise and spanwise direction, respectively; t time). The triangular wing in supersonic stream is supposed to have supersonic edges only. Strip theory means that each narrow chordwise parallel strip is taken aerodynamically as a portion of an infinite unswept wing.

It is shown by elementary considerations that strip theory always gives exact results in determining the contribution of any flexible or rigid body mode to the generalized aerodynamic force on any mode which is, at most, of the first degree in y. Strip theory is applied to harmonic motion of supersonic delta wing with flutter modes represented by polynomials in x and y. For these motions the reverse-flow theorem makes the exact solution possible, thus giving another analytical proof of the mentioned result. It leads further to an analytical expression for the error involved in using strip theory when the body mode for which the generalized force is to be determined is not linear in spanwise direction. This error is calculated for Q_{jj} in some cases of harmonic motion (up to the fourth degree in y), showing sufficient accuracy of strip theory in many problems of practical interest.

H. Behrbohm, Sweden

2087. Nonweiler, T., The wave drag of highly swept wings; a comparison of linear theory and slender body theory, *Coll. Aero. Cranfield Note* **14, 14 pp., Oct. 1954.**

This note comments on the comparison between the answer obtained by linear theory for the wave drag of slender wings (as interpreted by the limit $(M^2 - 1)^{1/2} \cot \Lambda \to 0$) and that value for the drag obtained by slender-body theory. It is shown that for fully tapered wings the agreement is exact, and that there is reason to suppose that the same is true for all wing planforms, unless the trailing edge is unswept or the wing section has a finite trailing-edge thickness. Some remarks are included concerning the drag of slender delta wings.

From author's summary

2088. Zienkiewicz, H. K., Load distributions on some twisted and cambered delta wings with supersonic leading and trailing edges, *J. aero. Sci.* **21, 6, 421–422, June 1954.**

Using Puckett's source distribution method, integral relations are developed for the load distribution outside the tip and subsonic leading-edge regions of symmetrically twisted and cambered wings with supersonic leading edges. These relations are used to calculate the load distribution on delta wings with the incidence distribution proportional to $x^p \mid y \mid^q$ for $0 \leq p, q \leq 3, 0 \leq p + q \leq 3$.

From author's summary

2089. Lomax, H., Lift developed on unrestrained rectangular wings entering gusts at subsonic and supersonic speeds, *NACA Rep.* **1162, 16 pp., 1954.**

Supersedes article reviewed in AMR **7**, Rev. 238.

2090. Just, W., On the calculation of the forces acting at the blade hinges of a helicopter and the six rotor force and moment components (in German), *Z. Flugwiss.* **1, 4, 100–104, Sept. 1953.**

Assuming a stiff blade, the forces (radial, tangential, and axial) and moments (torsional) acting at the blade hinges are obtained. Hinge offset is considered. The general cases of forward flight

and autorotation are considered. The determination of the aerodynamic forces is not included in this paper but will be given in another report. Plots of the force and moment variation with blade azimuth angle are given.

The rotor derivatives (*H-Y-Z* forces and moments) contributing to the motion of the fuselage are then derived.

The analysis is conventional and therefore is limited by the rigid blade and downwash assumptions. These usually account for an appreciable error between theory and experimentation.

L. Goland, USA

2091. **Raspet, A., Application of sailplane performance analysis to airplanes,** *Aero. Engng. Rev.* **13,** 8, 56–62, Aug. 1954.

2092. **Coles, W. D., Icing limit and wet-surface temperature variation for two airfoil shapes under simulated high-speed flight conditions,** *NACA TN* 3396, 33 pp., Feb. 1955.

Report evaluates, both analytically and experimentally, the susceptibility of aircraft wing surfaces to icing. Two symmetrical airfoil sections (diamond and double-circular-arc) are used for the investigation. Results encompass a Mach number range from 0.6 to 1.35 and pressure altitudes from 25,000 to 40,000 ft.

Susceptibility to icing is analyzed from two standpoints: (1) The wet-surface temperature attained by the surface subjected to a given stream condition, and (2) the stream conditions for which ice will just start to form (i.e., the icing limit). The experimental investigation gave values of wet-surface temperatures in substantial agreement with calculated values. Location of the initial formations of ice also could be predicted satisfactorily. Calculated values of the icing-limit conditions, however, consistently predicted formation of ice at ambient air temperatures up to 12° F higher (average 7°) than the values determined by experiment. Fortunately, the calculated values err on the conservative side.

N. R. Bergrun, USA

2093. **Millar, D. A. S., Increase of engine icing due to inertia separation of cloud droplets in high speed flight,** *Proc. 2nd Canadian Symposium of Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* 280–287, Feb. 1954.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 2080)

2094. **Migotsky, E., Some considerations on two-dimensional thin airfoils deforming in supersonic flow,** *NACA TN* 3386, 36 pp., Jan. 1955.

A recurrence relation for the generalized force coefficients for indicially cambered two-dimensional airfoils in a supersonic flow has been determined theoretically from the response of an indicially plunged airfoil. The rate of energy input required to sustain a general time-dependent chordwise deformation has been obtained in terms of these indicial functions. The particular case of a parabolic chordwise bending mode was considered in detail, and stability boundaries were obtained which show that this mode is unstable only for Mach numbers less than 0.65. In addition, it has been shown that a beam with parabolic thickness distribution has a quadratic fundamental chordwise bending mode in vacuo.

From author's summary by R. C. Roberts, USA

2095. **Gessow, A., and Crim, A. D., A method for studying the transient blade-flapping behavior of lifting rotors at extreme operating conditions,** *NACA TN* 3366, 27 pp., Jan. 1955.

Differential equations for the flapping motion of free-to-cone and seesaw rotors are derived without restriction as to blade geometry or mass distribution, but assuming the blades to be rigid in torsion and in bending. By computing the aerodynamic forces from the appropriate airfoil section data, factors encountered in extreme operating conditions (such as blade stalling and compressibility effects) are satisfactorily taken into account. A numerical (step-by-step) method using automatic computing machinery is proposed for the solution of the equations. By way of examples, results are given for blade stability at high tip-speed ratios and for transient flapping response to arbitrary control inputs.

C. Scruton, England

2096. **Reese, J. R., and Sewall, J. L., Effective moment of inertia of fluid in offset, inclined, and swept-wing tanks undergoing pitching oscillations,** *NACA TN* 3353, 27 pp., Jan. 1955.

Fuel in a tank does not, in general, behave like a solid when the tank is moved; hence, such an assumption ordinarily leads to an incorrect estimate of the forces and moments required to oscillate the tank. The problem of determining the true forces and moments then arises. This problem is important when the weight of fuel in an airplane wing tank is comparable with the wing weight, since wing flutter characteristics may be affected.

Several model tanks were tested full and partially full. Each tank was attached to a torsional spring and given an initial displacement. The effective moment of inertia was calculated from the observed frequency and the known stiffness of the torsional spring. Several springs of different stiffness were used to determine the effect of frequency. Tanks were tested with and without baffles and in various positions relative to the axis of the torsional spring.

The effective moment of inertia was nearly independent of frequency for frequencies well above the fundamental value for the fuel. Simple approximations for estimating effective moments of inertia are suggested for some configurations. Full tank cases are shown to agree reasonably well with theory. Baffles increased the effective moments of inertia. Diffused baffles showed good damping for partially full pylon mounted tanks.

Reviewer suggests that comparison with available theory for unbaffled partially full tanks should be made. This might help to correlate experimental data.

E. W. Graham, USA

2097. **Pian, T. H. H., Foss, K. A., and O'Brien, T. F., Effect of structural flexibility on aircraft loading,** *AF tech. Rep.* 6358, part XX, 92 pp., Apr. 1954.

Report is a summary of nineteen previous reports written over a period of several years by the Aeroelastic and Structures Research Laboratory, M.I.T. Effects of elasticity are considered in four cases, namely, airload distribution on wings, gust loads, tail loads, and ground loads. For the first three problems good historical surveys are provided.

Study of lift distribution occupies half of paper. Graphs and formulas for making a quick estimate of the effect of elasticity upon the lift under various loading conditions are given. For approximate subsonic analysis, authors recommend method of Shrenk with Diederich's extension for sweepback. For accurate analysis, authors recommend Multhopp's equations with Weissinger's extension for sweepback. The only supersonic case presented is a delta wing with subsonic leading edges in which the lift due to elastic deformation is determined from slender-body theory.

In connection with the gust problem, graphs showing the growth of lift on a rigid swept wing are given. A simple criterion for estimating the effect of elasticity upon the gust load on a straight wing is given as well as an extensive discussion of the effect of various parameters. For accurate analysis, authors seem to prefer Houbolt's method in which spatial derivatives are replaced by finite differences and time integration is done in a

step-by-step numerical procedure, all work being done on a digital computer. Advantages to be gained by using a true dynamic analog computer (electrical simulator), such as the CalTech Analog Computer, are not mentioned.

Effect of elasticity of wing and fuselage upon tail loads in maneuvers was investigated for various simplified cases. For horizontal tail, effect is unconservative and of sufficient magnitude in flexible aircraft that it should be considered. Effect on vertical tail loads is of lesser importance. An approximate method of estimating this effect is given.

Ground loads, having been treated thoroughly in a previous report, are summarized briefly with recommendations for future research. This summary paper, with previous nineteen reports, provides a large amount of valuable information for design and for the writing of design specifications.

S. U. Benscoter, USA

Propellers, Fans, Turbines, Pumps, etc.

(See Revs. 1926, 1939, 2034, 2035, 2036, 2098, 2154, 2160)

Flow and Flight Test Techniques

(See also Revs. 1916, 2056, 2187)

2098. Kastner, L. J., and Williams, T. J., Pulsating flow measurement by viscous meters, with particular reference to the air supply of internal-combustion engines, *Instn. mech. Engrs.*, 3–16, Feb. 1955.

In a "viscous meter, a stream is directed through a number of narrow passages, across which the pressure difference is measured and in which the Reynolds number is kept so low that the flow is laminar." Consequently, the response of the sensing element to velocity fluctuations is linear and the meter is especially suitable for the measurement of pulsating flow. The paper presents a thorough experimental study of the performance of such meters under the most severe conditions of pulsating flow, and includes design criteria and specifications which, in the opinion of the reviewer, will add considerably toward the development of accurate viscous meters, especially for the purpose of measuring air consumption of reciprocating-internal-combustion engines.

A. K. Oppenheim, USA

2099. Fisher, J. H., Electromagnetic flowmeter design and performance considerations, *Trends Engng., Univ. Wash.* **7,** 1, 18–23, Jan. 1955.

2100. Conklin, R. M., and Morgan, H. M., Transducers for measuring displacement, velocity, or acceleration, *Prod. Engng.* **25,** 12, 158–162, Dec. 1954.

2101. Smiley, E. F., and Winkler, E. H., Shock-tube measurements of vibrational relaxation, *J. chem. Phys.* **22,** 12, 2018–2022, Dec. 1954.

Paper describes an experimental interferometric measurement of vibrational relaxation in carbon dioxide and chlorine gases from 1400 K to 1500 K. The density behind the shock front was assumed to decay exponentially to an equilibrium value from its value immediately behind the front. The distance for decay to within $1/e$ of its equilibrium value was measured as a characteristic distance and related to the relaxation time by a simple but adequate theory. Experimental results are also reported on Cl_2-10% He and CO_2-10% H_2O mixtures.

The experimental results agree within their accuracy with existing acoustical data. Estimated accuracy (from $^1/_{20}$ fringe shift error) of ± 20 to $\pm 50\%$ agrees well with actual scatter in the data.

Authors discuss limitations of the method.

R. A. Strehlow, USA

2102. Henshall, B. D., The shock tube, *J. roy. aero. Soc.* **58,** 524, 541–546, Aug. 1954.

2103. Dosanjh, D. S., Use of a hot-wire anemometer in shock-tube investigations, *NACA TN* 3163, 98 pp., Dec. 1954.

In addition to a general discussion of hot-wire and shock-tube theory, emphasis is given to response of hot-wire to transient step function change in flow conditions (e.g., shock wave). Response is experimentally studied and the criterion for necessary compensation required is postulated and experimentally verified.

Principal advantages of hot-wire technique appear to be in timing very weak shock waves or expansion waves as well as measurement of ultimate temperatures in various flow regions. Main disadvantage is appreciable response time, even with large electronic compensation.

R. L. Trimpi, USA

2104. Stever, H. G., and Bisplinghoff, R. L., The shock tube in aerodynamic and structural research, *Proc. nat. Acad. Sci. Wash.* **40,** 7, 557–565, July 1954.

After a discussion of the basic theory of the shock tube the authors report on the use of a large (6 in. × 24 in.) shock tube as a short-duration wind tunnel for structural testing in the transonic range. Both the aerodynamic forces and the transient response of the structure can be investigated. However, reliable determination of ultimate failing strengths would require a much larger shock tube.

Reviewer believes that a more detailed report describing the instrumentation and giving test results would be of great interest to workers in the field.

W. Squire, USA

2105. Staite, H. J., Leakage rates from pressurised aircraft at altitude, *J. roy. aero. Soc.* **58,** 524, 574–577, Aug. 1954.

One of the routine ground tests carried out on pressurized aircraft is the measurement of the leakage rate, and this is often expressed in the form of a time for the cabin excess pressure to fall from a given value to half that value. The technician, however, is usually concerned with the functioning of the pressurized cabin at high altitude, and it is the purpose of this note to establish a means of forecasting the high-altitude performance from the sea-level test. The first part of the note describes the basic theory and provides a unique relationship connecting leakage times at any height with that pertaining to the sea-level test. The latter part of the note gives an example of the use of this information in predicting the fall off of cabin pressure after pressurization failure and with the aircraft descending.

From author's summary

2106. Brescia, R., Gibellato, S., Muggia, A., and Jarre, G., Some investigations on low Mach number wind tunnels (in Italian), *Aerotecnica* **34,** 4, 175–195, Aug. 1954.

A method for the rapid calculation of the power factor of wind tunnels is developed. The evaluation of losses is based on statistical considerations and the effect of contraction ratio is deduced theoretically. The speed pulsations of an open-jet wind tunnel are determined by experiments and some devices for their reduction are examined.

The results of some experiments on the thermal transmission and drag of various types of cooling radiators are reported. The experimental installation used is described.

From authors' summary by S. B. Berndt, Sweden

2107. **Laberge, J. G., and Conlin, L. T., A technique of manufacture of supersonic nozzles,** *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* 264–279, Feb. 1954.

2108. **Lukasiewicz, J., Drive and operation of large intermittent wind tunnels,** *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* 123–124, Feb. 1954.

2109. **McLellan, C. H., and Williams, T. W., Liquefaction of air in the Langley 11-inch hypersonic tunnel,** *NACA TN* 3302, 36 pp., Oct. 1954.

Pressure and scattered-light measurements were made in the Langley 11-in. hypersonic tunnel to determine the effect of stagnation temperature on the flow in two Mach number 7 nozzles and to determine the nature of the condensation process occurring at low stagnation temperatures. Liquefaction of the air occurred very close to the saturation point without a condensation shock, a result which indicated that liquefaction took place on foreign nuclei such as water and carbon-dioxide particles. The results from varying the water vapor and carbon-dioxide content, however, could not be correlated with Max Volmer's condensation theory. The average particle radius was 480 Ångstroms in the test section of the single-step Mach number 7 nozzle for stagnation conditions of about 530° R and 29 atmospheres. Under these conditions, about 10^{10} particles per cubic centimeter were present. From authors' summary

2110. **Schmitt, T. J., Wind-tunnel investigation of air loads on human beings,** *David W. Taylor Mod. Basin Rep.* 892, *Aero* 858, 14 pp., 39 figs., 3 tabs., Jan. 1954.

An investigation was conducted in the Taylor Model Basin 8- by 10-ft subsonic, atmospheric Wind Tunnel 2 to determine the drag coefficient of man. Tests were made at several yaw angles with subjects of various sizes in five body positions: standing, sitting, supine, and two squat positions. Data were obtained for the subjects in both the clothed and nude conditions.

A parameter was formulated from the available physical characteristics of the subjects tested and all coefficients were based on this. Drag coefficients were obtained which should be reliable in predicting drag forces on men of average stature under a variety of conditions. Lift, side force, and moments were also obtained which indicate relative trends of motion for each position. From author's summary

Thermodynamics

(See also Revs. 2010, 2055, 2078, 2101, 2154, 2159, 2162, 2168, 2172, 2173)

2111. **Koga, T., A proposal for fundamental equations of dynamics of gases under high stress (A proposal for statistical mechanical treatment of systems not in thermal equilibrium associated with transport phenomena),** *J. chem. Phys.* **22,** 10, 1633–1646, Oct. 1954.

The fundamental equations of gas dynamics are derived which are valid for flow at high shearing stress, thus obviating the limiting assumption of the current hydrodynamical equations where it is considered that the states of the gas depart only slightly from thermal equilibrium.

The state of the gas in an intermediate volume element is microscopically represented in terms of the transport quantities. Considering their averages over an intermediate time interval, an attempt is made to find the statistical character of the system; i.e., under the assumption that the microscopic law can be established, it is shown that the Boltzmann-Planck method in a new sense is applicable to the systems considered. A new distribution function is derived which does satisfy the Boltzmann-Maxwell equation. This is shown by using Kirkwood's verification accepted in a somewhat extended meaning.

The author presents new equations of continuity, momentum, and stress obtained as a result of his distribution function where mass density, velocity of mass motion, and stress are the essential variables. So far as the general form of the fundamental equations is concerned, the method of treatment is similar to that of Enskog and Chapman's, with some modifications. In the proposed equations a new conception arises; namely, that of conductivity of stress, instead of the usual viscosity and thermal conductivity. The results are applicable only to rarefied gases.

G. A. Hawkins, USA

2112. **DuMond, J. W. M., Variety of our sources of information on Avogadro's number and other constants,** *Phys. Rev.* **94,** 6, p. 1790, June 1954.

2113. **Prigogine, I., and Mel, H. C., Stability of thermodynamic equilibria** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5e) **40,** 6, 588–599, 1954.

Author considers a system in which a number of chemical reactions can take place and the deviations from equilibrium are small. He defines thermodynamic stability by the condition that each perturbation of the chemical equilibrium is accompanied by a negative entropy production, and kinetic stability by the condition that the perturbed system returns to equilibrium in course of time. The following theorems are proved: (1) Thermodynamic stability and the existence of a thermodynamic potential, together, imply kinetic stability whether the Onsager relations hold or not. (2) Assuming thermodynamic stability while no thermodynamic potential exists, kinetic stability generally holds only if the Onsager relations are satisfied.

Reviewer remarks that the use of the Hurwitz stability criteria could be avoided and the proof thus simplified and generalized by using the relation $\Sigma \xi_i \dot{\xi}_i / a_{ii} < 0$, which follows easily from Eq. (5.18). J. Meixner, Germany

2114. **Zwanzig, R. W., Kirkwood, J. G., Stripp, K. F., and Oppenheim, I., The statistical mechanical theory of transport processes. VI. A calculation of the coefficients of shear and bulk viscosity of liquids,** *J. chem. Phys.* **21,** 11, 2050–2055, Nov. 1953.

The theory of the coefficients of shear and bulk viscosity of liquids [Kirkwood, title source, **14,** p. 180, 1946; Kirkwood, Buff, and Green, ibid., **17,** p. 988, 1949] is applied to the calculation of the coefficients of viscosity of liquid argon at its normal boiling point. The only empirical data required for the calculation are the two parameters in the Lennard-Jones potential, which are obtained from the second virial coefficient of the gas, and a small correction factor required to obtain agreement between the experimental and calculated equilibrium pressure of the liquid. The agreement with the experimental values is gratifying, considering that the three adjustable parameters are obtained from thermodynamic properties only. S. Gratch, USA

2115. **Zwanzig, R. W., Kirkwood, J. G., Oppenheim, I., and Alder, B. J., Statistical mechanical theory of transport processes. VII. The coefficient of thermal conductivity of monatomic liquids,** *J. chem. Phys.* **22,** 5, 783–790, May 1954.

A molecular theory of thermal conductivity of liquids is developed from Kirkwood's general theory of transport properties [title source, **14,** p. 180, 1946]. The thermal conductivity of

liquid argon at its normal boiling point is evaluated using the Lennard-Jones intermolecular potential. The empirical quantities required for the calculation are obtainable directly from thermodynamic properties only. The agreement with experiment is excellent. S. Gratch, USA

2116. Schultz-Grunow, F., Thermodynamic heat flow (in German), "Mémoires sur la mécaniques des fluides," *Publ. sci. tech. Min. Air, Paris*, 309–311, 1954.

This is a brief note describing an experiment with a special Hilsch-Rangue vortex tube to confirm the author's view that heat may be transferred in vortex flow from a lower to a higher temperature region across the flow. Those working in this field will find the experiment of interest and possibly of importance. No discussion of theory is given.

The vortex tube, using air at 1.2 atm, was arranged in the form of a tight helix about a water-carrying inner core and was surrounded by a second outer water jacket. Heat was shown to flow from the inner core to the outer jacket in the uphill temperature direction across the air stream. F. C. Hooper, Canada

2117. Barzelay, M. E., Tong, K. N., and Hollo, G., Thermal conductance of contacts in aircraft joints, *NACA TN* 3167, 47 pp., Mar. 1954.

Tests were conducted to determine the factors influencing the thermal conductance across the interface between 75S-T6 aluminum-alloy and AISI type 416 stainless-steel structural joints. From the results it was concluded that (1) the thermal conductance of the interface joint increases with mean temperature level, while it remains approximately constant with changes in heat flow; (2) thin foils of good conducting materials inserted between the interfaces improve the heat transfer noticeably; (3) common strength-giving bonding materials produce joints with very poor thermal conductivity; and (4) none of the three modes of heat transfer (metal-to-metal conduction, air-film conduction, and radiation) has any predominance over another across the interface joints and, furthermore, there is an interdependence among these three which has not previously been recognized.

From authors' summary

2118. Bednar, J., A new method for the absolute measurement of the thermal conductivity of small samples (in Russian), *Czech. J. phys.* **3**, 2, 168–169, 1953.

2119. Westmoreland, J. C., Determination of viscosity of exhaust-gas mixtures at elevated temperatures, *NACA TN* 3180, 41 pp., June 1954.

The viscosities of five samples of dry-exhaust-gas mixtures at approximately atmospheric pressure and at temperatures from 0 to 1100 C are presented. A method of analysis and correlation proposed by Sutherland has been applied to the data and equations were derived therefrom for representing the results. It is believed that these equations may be used for computing viscosities of all mixtures having compositions within the range of the five studied at any temperature up to about 1300 C. The effect of moisture upon the viscosity of exhaust gas was computed by a relation developed from experimental values for moist air.

From author's summary

2120. Tykodi, R. J., Thermodynamics of adsorption, *J. chem. Phys.* **22**, 10, 1647–1654, Oct. 1954.

The thermodynamics of the adsorption of gases on solids is developed in terms of a two-component system. It is shown that all solids swell during the adsorption process, and that spontaneous first-order phase changes in the adsorbed layer are unlikely. The ideal process: i(gas) → i(adsorbed)—constant environment—is introduced and discussed; thermodynamic functions appropriate to the process are defined. Two types of heat capacity of the adsorbed layer are defined and discussed. The chemical potential of a solid is treated at some length.

From author's summary

2121. Lakhanpal, M. L., Sud, R. K., and Puri, B. R., Influence of capillarity on the boiling point of water, *J. phys. Chem.* **59**, 2, 160–161, Feb. 1955.

An apparatus for determining boiling points of capillary condensed moisture has been described. Boiling points of water held up in four different porous bodies, at different relative vapor pressures, were determined by means of this apparatus and the results obtained were compared with the theoretical values derived from thermodynamic considerations. The results offer support to the theory of capillary condensation. From authors' summary

2122. Mitra, S. S., Variation of vapour pressure with temperature, *J. Indian Chem. Soc.* **31**, 6, 444–446, June 1954.

The variation of vapor pressure of liquids with temperature has been studied and a new formula expressing the variation is proposed. From author's summary

2123. Michels, A., Wassenaar, T., Levelt, J. M., and de Graaff, W., Compressibility isotherms of air at temperatures between −25 C, and −155 C and at densities up to 560 amagats (pressures up to 1000 atmospheres), *Appl. sci. Res. (A)* **4**, 5/6, 381–392, 1954.

Compressibility isotherms of air at temperatures from −25 C down to −155 C and for densities up to 560 Amagats were measured. The results, including some data in the two-phase region, are presented. Conclusions are drawn for the position of a part of the coexistence boundary line. From authors' summary

2124. Paschkis, V., Solidification of cylinders, *Trans. Amer. Foundrymen's Soc.* **61**, 142–149, 1953.

Paper deals with the time of solidification of cylindrical steel castings of 2 in. in diameter and length. All results were computed from the Heat and Mass Flow Analyzer and are presented (a) in the form of graphs showing the isochrones for the liquidus and the solidus and (b) in the form of tables. The latter lists time of solidification for 28 different locations in a diametral plane of the cylinder.

Temperature at the casting-sand interface is assumed to be held constant at the Riemann temperature (2444 F) and, optionally, for 40 or 20 sec at the Riemann temperature and then dropped to 90% of that value. A constant pouring temperature of 2845 F is used in all cases.

It is found that the total probable solidification time of the steel casting is between 83 and 116 sec, depending upon the assumed variation of temperature at interface.

B. T. Chao, USA

2125. Paschkis, V., Solidification of finite cylinders, Amer. Foundrymen's Soc. Ann. Meet., Cleveland, Ohio, May 1954. Prepr. 54–31, 5 pp.

This is an extension of author's previous work on the solidification of cylindrical steel castings (see preceding review). Effect of variation of temperature at the steel-sand interface on the time of solidification was further studied for cylinders of various length-to-diameter ratios. It is found that for L/D ratio of 3 or greater, the total solidification time is within 5% of that for an "infinitely long cylinder." Generalized solidification curves both for the liquidus and the solidus are presented so that for

steel cylinders of any shape the solidification time can be computed with ease. A simplified equation developed from the concept of thermal resistance is also given for approximate calculation.

Based upon the results of the present investigation, author discusses the limitations of Chworinoff's theory.

B. T. Chao, USA

2126. **Sears, G. W., A note on the flow of gases through very fine tubes,** *J. chem. Phys.* **22,** 7, 1252–1253, July 1954.

It is shown that Knudsen's laws of flow for rarefied gases must be modified for very fine tubes. Gas flow occurs by diffusion of molecules in the adsorbed layer on the tube walls as well as in the gas phase. When the tube dimension is comparable to the mean free path in the gas film, the two flow mechanisms become comparable in effectiveness. From author's summary

2127. **Godridge, A. M., and Thurlow, G. G., A water-separating cyclone,** *J. sci. Instrum.* **31,** 7, p. 258, July 1954.

2128. **Young, T. F., Kraus, K. A., and Johnson, J. S., Thermodynamics of equilibrium in the ultracentrifuge,** *J. chem. Phys.* **22,** 5, 878–880, May 1954.

2129. **Landsbaum, E. M., Dodds, W. S., and Stutzman, L. F., Humidity of compressed air,** *Indust. Engng. Chem.* **47,** 1, 101–103, Jan. 1955.

The figure of this article has been deposited as Document no. 4407 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. Ed.

2130. **Bologna, G. F., Experiments on low temperature starting of internal-combustion engines** (in Italian), *ATA* **6,** 5, 373–377, Feb. 1953.

2131. **Beldecos, N. A., and Smith, A. K., Comparative performance of turbine-generator units in saturated-steam cycles,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-65, 14 pp.

Paper extends performance data for central-station turbine-generator units into the region of saturated steam where few or no data are available for large unit ratings. A performance level and trend is established which is representative of that which can be anticipated with present-day turbine practice. Turbine-generator performance is confined to units of 100 Mw capability or greater to coincide with the trend in unit ratings for central-station application. The performance data are supplemented by a brief review of turbine-design considerations. In the region of saturated steam, some method of moisture reduction is required. The various schemes are reviewed and a comparison made to establish the relative merits of the moisture separator and steam reheater. Paper further illustrates the relative effect of the principal cycle parameters, thus making possible the evaluation of the saturated-steam cycle.

From authors' summary

2132. **Macioce, E., Some thermodynamic and propulsive considerations on rocket motors** (in Italian), *Aerotecnica* **34,** 4, 196–203, Aug. 1954.

After some general considerations on performance rates of a rocket motor, the fundamental equation of propulsion with reference to the relativisitic mechanics is established. From this equation the equation of classical mechanics is deduced.

Finally, the problem of escaping from earth gravitational field is considered. From author's summary

Heat and Mass Transfer

(See also Revs. 2010, 2041, 2055, 2092, 2093, 2114, 2115, 2117, 2124, 2125, 2162)

2133. **Shaw, C. H., and Saunders, N., Intermediate laboratory experiment in heat conduction,** *Amer. J. Phys.* **23,** 2, 89–90, Feb. 1955.

2134. **Squassi, F., Some characteristic properties of heat insulation** (in French), *Chaleur et Industrie* **35,** 349, 215–221, Aug. 1954.

2135. **Lietzke, A. F., Theoretical and experimental investigation of heat transfer by laminar natural convection between parallel plates,** *NACA TN* 3328, 23 pp., Dec. 1954.

Theoretical investigation assumes fluid totally enclosed between infinite plates, constant vertical temperature gradient, zero midplate velocity, and constant fluid properties except for bouyancy effect. Experimental data were obtained for an annulus of 1.375 diameter ratio otherwise approximating conditions of theoretical study. Results are shown for both investigations as ratio of temperature difference across fluid to that for pure conduction. Purpose is stated to be to determine validity of assumptions of theory, and good agreement is obtained for range of investigation.

Reviewer feels that experimental configuration differs too greatly from geometry of theoretical case to permit conclusions. A closer matching of idealization to experiment is in order for further work on the problem. Report would be more satisfactory if units were omitted from quantities listed in page of symbols and dimensions of quantities shown instead. Reviewer believes the assumption of zero viscous force (and velocity) midway between plates can be avoided without undue mathematical complication, to strengthen the analysis. W. Rice, USA

2136. **Etemad, G. A., Free-convection heat transfer from a rotating horizontal cylinder to ambient air, with interferometric study of flow,** ASME Ann. Meet., New York, Nov. 28–Dec. 3, 1954. Paper 54—A-74, 11 pp.

See former review [AMR 8, Rev. 810]. The photographic illustrations of the previously reviewed paper were considerably larger and clearer, although identical. C. R. Mischke, USA

2137. **Bugaenko, G. A., Free convection in a slanted cylinder** (in Russian), *Prikl. Mat. Mekh.* **18,** 2, 212–214, Mar./Apr. 1954.

2138. **Seiff, A., Examination of the existing data on the heat transfer of turbulent boundary layers at supersonic speeds from the point of view of Reynolds analogy,** *NACA TN* 3284, 38 pp., Aug. 1954.

A graphical correlation is selected for the local skin-friction coefficient C_f as a function of Mach number M and temperature ratio T_w/T_1. This correlation is based on data selected as representative of the most significant published test results and on some preliminary results reported by the author for $M = 7.2$.

The ratio of Stanton number to the C_f values thus established is then considered. The Stanton number is evaluated from available heat-transfer results taken from six published references and from some new experiments of the author and Barbara J. Short.

All the results (including those for C_f) are adjusted to a consistent temperature basis for evaluation of the air properties. The Reynolds number is based on the effective length of the

turbulent region, evaluated on the assumption that the momentum thickness of the boundary layer should show no jump at the transition point.

The data cover a range of M from 1.4 to 3.2 at Reynolds numbers from 0.4 million to 2.4 million. They cover flat plates, cones, and slender bodies of revolution.

The results for the ratio of Stanton number to C_f all lie in the narrow band between 0.48 and 0.72, with a mean value of 0.61.

Considering the wide variety of the conditions covered, the results appear to support the modified Reynolds analogy remarkably well, in spite of various imperfections and accuracy limitations in the underlying experiments. Need for additional experiments is noted, both to extend the range of the variables considered and also to establish the possible influence of nonuniformities of surface temperature and pressure.

Reviewer notes that the author's friction-factor correlation, although a reasonable choice at the time, may deserve a slight but appreciable revision in consideration of more extensive subsequent data such as those presented in *NACA TN* 3391, March 1955. R. H. Norris, USA

2139. Rubesin, M. W., An analytical estimation of the effect of transpiration cooling on the heat-transfer and skin-friction characteristics of a compressible, turbulent boundary layer, *NACA TN* 3341, 56 pp., Dec. 1954.

The analysis assumes that the boundary layer may be considered as made up of two distinct sections, a laminar sublayer covered by a fully turbulent outer layer. The analysis not only relates heat transfer and skin friction under the influence of blowing but also includes the effects of such frictional dissipation as would occur in high-speed air flow. In the incompressible flow regime the results are in reasonable agreement with the limited data available. Much experimental work is necessary to give quantitative affirmation to the qualitative results. The transpiration cooling system is predicted to be highly effective even at supersonic speeds. The coolant (in this case air) absorbs a maximum amount of heat, thus reducing not only the surface temperature but also the skin friction. Calculations are made in the range of $0 < M < 4$ and $10^4 < R_x < 10^8$. The effect of the transpiration on the local recovery temperature, calculated for the incompressible case, is shown to be less than the effect of Reynolds number for the zero transpiration case.

Ione D. V. Faro, USA

2140. Gerard, G., Some structural aspects of thermal flight, Symposium on the Thermal Barrier, ASME Ann. Meet., New York, Nov. 28–Dec. 3, 1954. Paper 54—A-40, 9 pp.

The author diagrammatically explains recent growth trends in aircraft as a function of flight speed. Despite the remarkable increases in the gross weight of aircraft, the trend of the weight-strength ratio has been decreasing up to flight speed in the neighborhood of 1000 mph. An increase in the weight-strength ratio is foreseen as aerodynamic heating requires reduction of stress levels. With this reversal in the weight-strength trend in materials at elevated temperatures, the structures man possibly faces a truer barrier than did the aerodynamicist in the sonic barrier. An increase of 10% in the weight increment in a proposed aircraft increases the gross weight by 100% if original strength and performance are to be maintained, due to aerodynamic heating, structural, and propulsion requirements.

The author discusses the effect of structural configurations (i.e., solidity), relative efficiencies of materials subjected to tension, compression, and shear loadings, and life expectancy of aircraft. Where aerodynamic heating is of importance, the sustained structural temperature may well be below 800 F (Mach 3.5). The use of integral construction may result in substantial weight savings. Limited life expectancy of aircraft may be one solution to the rapidly rising gross weight problem.

C. R. Mischke, USA

2141. Li, T-Y, and Nagamatsu, H. T., The effect of heat transfer on the behavior of a compressible laminar boundary layer under favorable and adverse pressure gradients, *J. aero. Sci.* **21,** 12, 850–851, Dec. 1954.

Note in Readers' Forum.

2142. Palme, H. O., Aerothermodynamic heating of airplanes at high speeds (in Swedish), *Tekn. Tidskr.* **84,** 38, 903–907, Oct. 1954.

2143. Fultz, D., Nakagawa, Y., and Frenzen, P., An instance in thermal convection of Eddington's "overstability," *Phys. Rev.* **94,** 6, 1471–1472, June 1954.

The existence of modes of cellular convection driven by thermal instability which are oscillatory in type, rather than steady, has been predicted theoretically for systems that are rotating as a whole. Such modes are of a type called "overstable" by Eddington in a different connection. The result of an initial successful experiment with mercury is given.

From authors' summary

2144. Stewart, J. E., Absorption of radiant energy by solid particles in suspension, *J. Res. nat. Bur. Stands.* **54,** 1, 41–46, Jan. 1955.

A theoretical analysis of absorption of plane radiation by particles in a transparent medium and by an absorbing medium containing transparent particles is given. Both media have the same refractive index. The absorption depends upon particle shape and size. Large particles transmit more energy than small particles, whose behavior is similar to that of a condensed film of the same material.

Spectroscopic work on absorption by stearic acid suspended in various amounts of potassium bromide verifies the theoretical prediction that the mass of the suspending medium has a negligible effect. J. F. Davidson, England

2145. Aurén, T. E., Studies of solar radiation, *Ark. Geofys.* **1,** 5/6, 395–439, 1953.

Paper reports extensive studies of clear-sky solar radiation in Sweden. Instruments and methods of calibration are described. Topics treated include sky radiation near the sun, spectral composition of solar radiation and the solar constant. Comparisons are given with data for the United States.

A. Whillier, South Africa

2146. Marcus, N., A blackbody standard, *Instruments Automation* **28,** 3, 436–438, Mar. 1955.

2147. Tobias, M., and Stoppel, A. E., Condensation of vapors of water and immiscible organic liquids, *Indust. Engng. Chem.* **46,** 7, 1450–1455, July 1954.

Authors present data and suggest an equation for the rate of heat transfer in condensation on vertical tubes from mixtures of water and immiscible organic liquids. In proposing an analytical solution, authors assume that the organic liquid adheres to and streams down the tube, with the water condensing as drops on the organic liquid surface. From this assumption, the classical Nusselt equation for single component condensation is modified to take into account the thinning of the organic liquid layer by the water and the increase in effective film thickness because

of the water drops. The equation thus developed reasonably represents data for mixtures of benzene-water, *n*-heptane-water, and toluene-water, but fails to correlate data for carbon tetrachloride-water systems.

Paper also contains a description of the authors' experimental apparatus and a comprehensive summary of the work of previous investigators. Authors are to be commended on the tabular presentation of their data, which should provide a useful source of information for future investigators in this field.

R. L. Young, USA

2148. Tierney, J. W., Jr., Stutzman, L. F., and Daileader, R. L., Mass transfer in packed towers: Effect of liquid concentration on liquid film coefficient, *Indust. Engng. Chem.* **46,** 8, 1595–1601, Aug. 1954.

It is generally recognized that lower concentrations of volatile material in a liquid feed to a stripping column, as best represented by dissolved gas, yield lower liquid film mass-transfer coefficients k_La. Authors show that this also holds true for vaporization of a dissolved volatile liquid, namely, butanol in hexanol, finding that k_La is inversely proportional to the Schmidt number, the average molecular weight, and the logarithmic mean concentration of the less volatile carrier liquid.

It is recommended that liquid film coefficients for designing mass-transfer columns employing concentrated solutions be obtained from the usual correlations for dilute solutions, and corrected to the desired concentration by proportion with the above quantities.

C. F. Bonilla, USA

2149. Garner, F. H., and Grafton, R. W., Mass transfer in fluid flow from a solid sphere, *Proc. roy. Soc. Lond.* (*A*) **224,** 1156, 64–82, June 1954.

Mass transfer from a single spherical benzoic-acid particle to water flowing in viscous motion was studied. Reynolds numbers were restricted to values less than 1000. Visual observations of the flow patterns around the sphere were made by injecting streams of red ink or fine aluminum powder into the water stream. The data obtained show that the angle of separation of forward flow vs. Reynolds number curves changed slope at a Reynolds number of approximately 50 and also at a Reynolds number of approximately 500.

From the mass-transfer data collected and from certain theoretical considerations, authors present an equation for mass transfer from solid spheres to a fluid. This equation is written in terms of the mass-transfer coefficient, the partial diameter, the diffusivity, and the Grashof, Schmidt, and Reynolds numbers. By replacing the Schmidt number with the Prandtl number the equation should also apply to the analogous heat-transfer case.

L. Lapidus, USA

2150. Acharya, Y. V. G., Momentum transfer and heat diffusion in the mixing of coaxial turbulent jets surrounded by a pipe, Doctor's thesis, Technische Hoogeschool, Delft, 174 pp., 1954.

This dissertation gives the results of an investigation of the diffusion of heat and momentum that occurs in the mixing of two coaxial jets surrounded by a pipe. Experimental results are expressed in terms of a coefficient of turbulent friction and a relative coefficient of heat diffusion. The development of both coefficients was based on Prandtl's concept of transfer coefficient. It was found that (1) the coefficient of turbulent friction increased with the absolute value of the difference between the velocity of the primary stream and that of secondary stream, and (2) the coefficient of heat diffusion decreased with increase in secondary velocity. Some discrepancies were found in the experimental results. These discrepancies do not affect the validity of the qualitative results obtained, but the author feels that additional work should be done to improve the accuracy of the quantitative results.

All experiments were carried out on a single setup. The primary nozzle was 4.13 cm in diameter. The secondary tube was 20.65 cm in diameter and about 150 cm long. The range in the ratio of the velocity of secondary stream to that of primary stream was 0.15–2.18.

A brief summary of various theories about the spreading of free jets is given and the behavior of coaxial jets is discussed.

S.-M. Yen, USA

2151. Stahl, C. R., Liquid-metal-cooled reactors, *Mech. Engng., N. Y.* **76,** 12, 978–980, Dec. 1954.

See AMR **8,** Rev. 509.

2152. Neugebauer, F. J., A systematic and rapid procedure of computing approximate characteristic values pertaining to bare-tube cross-flow heat exchangers, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-40, 18 pp.

Basic equations for heat transfer, pressure drop, and heat-exchanger geometry are combined to reduce the number of variables in a heat-exchanger design problem. It is possible to rapidly compute the approximate dimensions required to obtain the specified heat transmission, pressure drops, and temperature differences for single-pass bare-tube cross-flow heat exchangers. The approximation is valid for exchangers greater than 10 rows deep. Several other limitations are discussed in the paper. The object of the procedure is to provide a fast method of surveying all combinations of tube diameters, lengths, numbers of tubes, and numbers of rows which are capable of the specified performance.

S. Zivi, USA

2153. Eggleston, G. E., and Brimley, D. E., Heat-exchanger selection by computation machine methods, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-47, 11 pp.

A method of selecting the optimum air-to-air heat exchanger for airplanes is presented. Conventional equations for heat transfer and pressure drop are manipulated into a form which expresses the penalty imposed by the heat exchanger on the airplane.

The approach is to calculate the power required to operate the exchanger and the added power required by the airplane because of the weight of the exchanger. This is done for numerous combinations of flow rates and dimensions, using an IBM 701 data-processing machine.

Results are presented as families of three-dimensional graphs. The optimum exchanger is selected as the one imposing the smallest power penalty on the airplane. The optimum is then tested for practical installation in the airplane and, if a compromise is required, an alternate is selected from the cases already calculated.

S. Zivi, USA

2154. Upton, H. E., Heat exchangers for internal combustion engines, *Trans. Inst. mar. Engrs.* **66,** 5, 101–112, May 1954.

Paper describes tubular heat exchangers used for the purpose of cooling (*a*) engine coolants, (*b*) lubricating oil, and (*c*) the pressure charge air. The performance of these three heat-exchange components has an influence on the efficiency of the engine while it functions as a machine for converting the heat in the fuel into shaft horse power.

Information is given on heat distribution, the systems of which the heat exchangers form part, while the following aspects are also discussed:

The closed system of engine cooling; oil coolers, their performance with reference to thermal instability and coring in low sea

water temperatures; automatic temperature control and valve arrangements; pressure charging and effect of charge air cooling.

Paper also examines details of design materials and general maintenance. From author's summary

2155. Brown, G., Theory of moist air heat exchangers, *Acta Polyt.* **147;** *Phys. appl. Math. Ser.* 2, 11, 32 pp., 1954.

See AMR 8, Rev. 1179.

2156. Houghton, T. E., and Nonhebel, G., A method of defining availability, service and output factors of steam boilers, *Proc. Instn. mech. Engrs.* **168,** 33, 831–836, 1954.

2157. Roose, R. W., Buckley, N. A., and Konzo, S., Outdoor-air supply and ventilation of furnace closet used with a warm-air heating system, *Univ. Ill. Engng. Exp. Sta. Bull.* 427, 49 pp., Dec. 1954.

2158. Widell, D. T., Heat balance of baking (in Swedish), *Tekn. Tidskr.* **84,** 38, 899–902, Oct. 1954.

2159. Case, J. W., New moisture-sensitive element for relative humidity, *Instrum. Automat.* **27,** 7, 1076–1077, July 1953.

2160. Brosinsky, H.-J., Heat transfer experiments on an Otto engine (in German), *Motortech. Z.* **15,** 3, 61–68, Mar. 1954.

Combustion

2161. Marble, F. E., and Adamson, T. C., Jr., Ignition and combustion in a laminar mixing zone, Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953, 21 pp.; Selected combustion problems, fundamentals and aeronautical applications, London, Butterworths Scientific Publications, Ltd., 1954, viii + 534 pp., 111–131; see also *Jet Propulsion* **24,** 2, 85–94, Mar.–Apr. 1954.

A temperature criterion for ignition is developed from the energy relation and the equation of conservation of combustible material. By means of a small perturbation method the conditions for ignition are developed. The example used is azomethane, and temperature profiles (distance from center line vs. mixing zone temperature) are plotted for various concentrations. The result is obtained that, although combustion in a laminar mixing zone shows no blowoff, the flame detachment becomes so great at low stream temperature that it exceeds the dimensions of any physical apparatus. For the development of laminar flame, an extension of the integral method introduced by von Kármán is used. By numerical integration and using azomethane values, various flame characteristics are developed, notably, temperature profiles (distance from undisturbed temperature vs. mixing zone temperature).

This paper represents an interesting analytical approach which gives reasonable results for the example used.

J. H. Davidson, USA

2162. Van Doornum, G. A. W., The spontaneous heating of coal, *J. Inst. Fuel* **27,** 165, 482–495, Oct. 1954.

In this paper a mathematical procedure has been developed for calculating the temperature rises which occur, due to self-heating reactions, in large coal stores. This procedure is outlined at length but has been simplified to some extent by grouping the factors which may be determined by experiment (i.e., the rate of heat generation by a specific coal and the effect of external conditions, etc.) into dimensionless parameters. These may then be used to calculate the temperature rise in the coal when stored under specified external conditions.

The author has described laboratory experiments to determine the rate of heat generation in certain coals and has shown that the equation

$$q = \sum_i A_i \exp(a_i V - \alpha_i t)$$

may be used to represent the rate of heat generation for the purpose of calculating the temperature rise. In this equation, q is the rate of heat generation and the reactivity is composed of several components, each characterized by an "initial reactivity" A_i, a temperature coefficient a_i, and a decay coefficient α_i. The temperature rise is represented by V and the time that has elapsed by t. Temperature rises calculated from this equation have also been found to agree with those observed in large-scale tests. Author notes that, for all the coals so far investigated, spontaneous combustion is likely to occur in coal dumps where both the initial self-heating intensity (A_i) is small and persistence of the heating process large (i.e., α_i small).

The published literature on this subject is large but exact treatments are few. This paper goes far towards rectifying this and it is hoped that the large-scale tests and further laboratory experiments envisaged by the author will clarify the problems still further. A. M. Godridge, England

2163. Berry, F. J., and Holt, M., The initial propagation of spherical blast from certain explosives, *Proc. roy. Soc. Lond.* (*A*) **224,** 1157, 236–251, June 1954.

Uncased sphere of explosive, whose products follow a polytrope with $\gamma = 3$, is detonated from center, in air. Paper analyzes mathematically the behavior of air and products near surface immediately after arrival of detonation wave. A strong but decaying shock enters air, followed by a nonhomentropic region of compressed air. Behind air-product interface, an *initially* uniform and homentropic region (g) precedes the strictly homentropic product expansion (e). Radius r and time t (in units of sphere radius and detonation time) are replaced by polar coordinates (R, θ) in the (r, t)-plane with origin at $r = 1, t = 1$. Solution in powers of $R^{1/2}$ with coefficients dependent on θ requires at boundary (ge) a second shock whose strength grows initially in proportion to R (whereas air shock strength decays at first in proportion to $R^{1/2}$). This generalizes a conclusion reached by Wecken [Mem. 14 m. Lab. Recherches Tech. Saint Louis, 1951] in numerical work. Although present analysis extends only to small R, it is presumed (op. cit.) that inner shock will ultimately reflect and intensify at product center and develop into the secondary blast wave observed experimentally and predicted by Whitham [title source, **203,** 571–581, 1950] at large distances. Theory is applied in a particular case. S. Paterson, Scotland

2164. Linnett, J. W., Some experimental results relating to laminar flame propagation, Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953, 19 pp.; Selected combustion problems, fundamentals and aeronautical applications, London, Butterworths Scientific Publications, Ltd., 1954, viii + 534 pp., 92–110.

An interesting review of the experimental work concerning the burning velocity, temperature variation, and chemical partial pressures in laminar flame propagation. Under burning velocity, five methods for measuring are discussed, starting with the flat flame method for slow flames and going on through the "soap bubble" method, the constant volume spherical flame method, the tube method, and the burner method. Three methods for measuring temperature are discussed, namely, direct measurement with a thermocouple, tracing flow lines of light dust particles, and the measurement of refractive index change. Several examples of each method are described. Finally, the author discusses some of the recent articles on composition dis-

tribution through a flame, including absorption and emission spectroscopy and mass spectroscopy.

The author points out that the experimental ability to measure burning velocities is very well developed. However, this ability is much less in the area of temperature distribution and virtually nonexistent for composition distribution, particularly for diffusion flames. Forty-one references are cited, mostly covering the past eight years. J. H. Davidson, England

2165. **Kumagai, S., and Kimura, I., The effect of turbulence on flame propagation in gases,** Fourth Symp. (International) on Combustion, 667–669, 1953; Baltimore, Md., Williams & Wilkins Co.

Authors show by schlieren-photograph sequences that time required for flame ignited on its periphery to fill a short cylindrical combustion chamber was cut to one half or one third when the flame passed through a grid, the effect being essentially the same for three grids having different size and number of holes.

In another combustion chamber, fitted with a vibrating wire netting for turbulence generation, flame growth rate after spark ignition was determined by correlation with chamber pressure rise. Results reported show a nearly linear relationship between flame speed and velocity of the netting. Scale and intensity of the turbulence are not reported. From the nature of the apparatus (and results) it seems likely that the turbulence produced was not isotropic and that during flame growth different parts of a flame globule would have been subjected to greatly different conditions of turbulence.

Both types of experiment are interesting qualitative demonstrations of turbulence effects, but dependence of results on apparatus used makes questionable their value for elucidating the mechanism of turbulent flame propagation.

W. P. Jensen, USA

2166. **Kumagai, S., Sakai, T., and Kimura, I., Effect of ultrasonic waves on flame propagation and spark ignition,** Fourth Symp. (International) on Combustion 143–151, 1953; Baltimore, Md., Williams & Wilkins Co.

In a variety of experiments, authors show that ultrasonic waves (270 and 500 kcps) noticeably accelerate flame propagation in homogeneous air-fuel mixtures, probably due to accelerated diffusion and heat transfer. Burning velocity increased about 15%, and flame front assumed a ragged form, but the latter is probably an indirect effect of the ultrasonic waves. No effect of ultrasonic waves on spark ignitability was detected, and authors suggest that the spark itself may cause disturbances similar to those of the ultrasonic waves. W. P. Jensen, USA

2167. **Spalding, D. B., A theory of the extinction of diffusion flames,** *Fuel* **33,** 3, 255–273, July 1954.

By assuming a reaction law of the Arrhenius type, this paper shows that, although the rate of consumption of fuel in a diffusion flame is determined by physical mixing process and influenced by air velocity and other factors, chemical considerations impose an upper limit on the combustion rate.

This upper limit (expressed in weight of fuel consumed per unit time per unit area of a diffusion flame) is shown to be of the same order as the rate of consumption in a luminar flame of the stoichiometric homogeneous mixture of the fuel and gas. This relation permits calculation of the gas stream velocity at which a flame surrounding a liquid fuel sphere is blown out. It appears that, at Reynolds numbers such that boundary-layer theory is applicable, the blowout velocity is proportional to the sphere diameter. Paper further shows that very small droplets cannot support a flame. M. A. Saleh, Egypt

2168. **Vichnievsky, R., Sale, B., and Marcadet, J., Combustion temperatures and gas composition,** *Jet Propulsion* **25,** 3, 105–118, Mar. 1955.

A previously developed method (by Ribaud) to determine combustion temperatures is discussed, and a new method (by Sale), resulting in a more concise determination of gas composition is presented. The system of eleven equations comprising carbon, hydrogen, oxygen, nitrogen balance, and the equilibria of seven dissociation reactions is solved by means of charts or by a semigraphical iteration. (Note of the reviewer: A solution of the same problem by numerical iteration is given by S. Traustel, *Brennstoff-Wärme-Kraft* **6,** 5, 163–165, 1954.)

W. Gumz, Germany

2169. **Hett, J. H., and Gilstein, J. B., Indicated instantaneous temperatures of liquid rocket exhausts and combustion chambers,** *Jet Propulsion* **25,** 3, 119–127, Mar. 1955.

A method is described to measure indicated instantaneous temperatures of the exhaust and combustion-chamber flames of a 1500-lb-thrust alcohol-oxygen rocket, based on the fact (as shown by A. Schack) that the radiation in the continuous background of the spectrum of a hydrocarbon flame is in thermal equilbrium with the gas. Light emitted from the flame is focused by a lens through a filter to a photomultiplier (1) and from a mirror located behind the flame through the same filter to a second photocell (2), the temperatures and emissivities being inferred from the two intensities. Details of apparatus used, window design, and corrections by means of a tungsten strip lamp are given. Indicated temperature of the exhaust was, e.g., 1900 K ± 50, emissivity 0.15 ± 0.05 (Kurlbaum method).

The necessity of spectral investigations is emphasized because gray radiation is found only in certain ranges of the spectrum. Flame temperatures in the combustion chamber determined by the same method with a modified method of interpetation of spectra were 2700 K, average emissivity $k = 0.47$. Temperatures were found lower than theoretical, the spectrum showing considerable deviation from the Planckian curve with a peak at 4700 Å, a slope from 5000 to 6000 Å, calling for future spectral work on rocket combustion chambers at different points of the flame path. W. Gumz, Germany

Acoustics

(See also Revs. 1933, 1935, 2166)

2170. **Hueter, T. F., and Bolt, R. H., Sonics—techniques for the use of sound and ultrasound in engineering and science,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xi + 456 pp. $10.

Many applications of sound waves have been proposed and tried for industry. The manufacturer who is not certain, because acoustics is perhaps a strange technique to him, whether to take claims made for these at their face value needs some guidance. It is, perhaps, the main object of this book to give this guidance; to explain the basis of the techniques; to show what the apparatus looks like; to distinguish what may be done on the plant scale from what has only been accomplished in the laboratory.

The authors, with their considerable experience as consultants and lecturers, have fulfilled this task well. They make free use of electrical analogs and impedance methods, realizing that many engineer readers will be more accustomed to electrical than to acoustical symbols. A good feature is the number of tabular expositions of comparative types of transducers, etc.

Among subjects treated in a detail which we have not noticed in other textbooks, may be noted: design of magnetostriction and piezoelectric applicators, sonic forces on particles in a fluid,

cavitation, fluid-dynamic transducers. The book can be recommended without reservation to all who wish to apply acoustic methods in all branches of engineering.

E. G. Richardson, England

2171. Baumeister, G. B., Production testing of bonded materials with ultrasonics, *ASTM Bull.* no. 204, 50–53, Feb. 1955.

Data correlating the various parameters with the extent of unbonded area, and typical industrial applications of ultrasonics for detection of lack of bond. From author's summary

2172. Carrier, G. F., The mechanics of the Rijke tube, *Quart. appl. Math.* **12,** 4, 383–395, Jan. 1955.

Author mathematically analyzes in detail the mechanism of the Rijke or gauze tone. Some experimental confirmation of the theoretical predictions is presented.

The solutions for wave propagations in a tube containing a moving stream is obtained. The corresponding open end conditions are also derived. The solution for the heat transfer from the grid to an oscillating gas stream is derived separately. The solutions are then combined and the eigenvalve problem solved. Second-order terms are dropped throughout, and necessary appropriations made; however, the author carefully justifies each step.

Author shows that phase lag between velocity and heat release rate varies from zero for large value of $\omega k/\rho c_p U^2$ (hot-wire instrumentation) to $3\pi/8$ for small values, which latter condition corresponds to that in the Rijke experiments.

A. A. Putnam, USA

2173. Collins, F. C., and Navidi, M. H., The calculation of the free volumes of liquids from measurements of sonic velocity, *J. chem. Phys.* **22,** 7, 1254–1255, July 1954.

Equations have been proposed by Eyring and Kincaid and by Kittel for relating the free volume of liquids to the velocity of sound. The Eyring-Kincaid equation was derived using a geometrical, rather than a thermodynamic, interpretation of the propagation of sound in a liquid, while Kittel used a very approximate form of the free volume equation of state in obtaining the relationship. In this paper, a more exact equation is derived and is compared numerically with those mentioned above in the cases of several liquids. From authors' summary

2174. Ferrero, M. A., and Sacerdote, G. G., Acoustic impedance measurement using a resonance method, *Acustica* **4,** 3, 359–364, 1954.

The method of C. M. Harris for acoustic impedance measurements, wherein a system is brought to resonance, is theoretically discussed and extended. Some experimental results obtained with equipment applying the method are also reported.

From authors' summary

2175. Exner, Marie-Luise, Autocorrelation and frequency analyses of a series of aperiodic time events (in German), *Acustica* **4,** 3, 365–379, 1954.

Autocorrelation and frequency analyses of a series of aperiodic time events, especially filtered noises and hisses, have been made. The position and band width of the frequency range are best obtained from the frequency analysis, but the energies contained in the several bands are most easily obtained from the autocorrelation function.

The mean number of null points of the time function is estimated from the curvature of the latter function in the vicinity of the null point and also with the aid of a decimal counter. The second method is found to be more exact.

From author's summary

2176. Richardson, E. G., Acoustic methods of measuring relaxation spectra in solids, *Acustica* **4,** 5, 537–543, 1954.

This tutorial paper describes several experimental techniques currently used in measurement of viscoelastic systems with one relaxation time. Scattering, models, and origins of internal friction are discussed. Twenty-two references are given.

V. Salmon, USA

2177. Ingard, U., On the theory and design of acoustic resonators, *J. acoust. Soc. Amer.* **25,** 6, 1037–1061, Nov. 1953.

Article gives design charts for optimum design for maximum resonance absorption of acoustic resonators. In the theoretical part are discussed, first, absorption and scattering from resonators in a free field and in walls. Special attention is given to the "end corrections" of the length of the aperture neck. The latter are calculated for an eccentric circular aperture in a circular tube and for concentric circular and rectangular apertures in a rectangular tube. Also, the interaction between adjacent apertures is considered. Further topics are the effect of viscosity, heat conduction, and the nonlinear losses caused by turbulence. Most results are verified by experiments. Examples are included for the optimal design of a spherical resonator with circular aperture of given thickness to radius ratio and given resonance frequency or resonator volume.

Also the case of several resonators in a wall, i.e., a perforated wall, is discussed. W. H. Muller, Holland

2178. Ingard, U., The near field of a Helmholtz resonator exposed to plane wave, *J. acoust. Soc. Amer.* **25,** 6, 1062–1067, Nov. 1953.

The near field of a spherical Helmholtz resonator exposed to a plane wave is computed and shown to be in good agreement with measurements. Comparison is made with the near field of a resonator terminating a cylindrical tube. A discussion of the calculation of the dissipation in the resonators is included.

From author's summary by W. H. Muller, Holland

Ballistics, Detonics (Explosions)

(See Revs. 1999, 2163)

Soil Mechanics, Seepage

2179. Keil, K., Earth dam construction: General principles and soil mechanics of earth dams and embankments [**Der Dammbau. Grundlagen und Geotechnik der Stau- und Verkersdämme**], **2nd ed.,** Berlin, Springer-Verlag, 1954, xiv + 581 pp., 600 figs. DM 69.

The first edition (1938) was limited to embankments for automobile highways. The new one is an excellent treatise on the whole problem of earth-dam construction for water storage and for roads. First part contains general principles: types of fill, stability, materials, their physical and mechanical properties; work organization; excavation, hauling up, clearing, bonding to foundation, dry fill, wetting and rolling; hydraulic fill; machinery. Second part is dedicated to soil mechanics: requirements of material, testing; artificial compaction; soil stabilizing—mechanical and chemical (hydration); vertical settlement and horizontal displacement; drainage; dangers and damages, causes of failure; relation between dam and its foundation; embankments and levees. An extensive bibliography (500 titles, among them about 125 American) adds to this carefully edited book. Book is important for civil engineers; an English translation would be of great value. S. Kolupaila, USA

2180. **Rowe, P. W., A stress-strain theory for cohesionless soil with applications to earth pressures at rest and moving walls,** *Géotechnique, Lond.* **4,** 2, 70–88, June 1954.

A stress-strain theory is proposed which utilizes Rankine's earth-pressure theory and values of internal and wall friction angles which are modified to allow for partial mobilization of the soil mass. It is hypothesized that the mobilized frictional resistance is a function of intergranular movement along slip planes.

Standard shear tests and compression tests give the relationship between slip strain and friction angle. However, modifications are proposed for confined compression test equipment which alleviate some of the errors inherent in standard equipment.

Reviewer believes that more field data should be obtained before the theory is used with confidence in engineering practice.
J. A. Cheney, USA

2181. **Smith, R. V., and Williams, R. H., Measurement of resistance to flow of fluids in natural gas wells,** *J. Petr. Technol.* 6, 11, 41–48, Nov. 1954.

Before this paper was presented, the terms f and $(1/f)^{1/2}$ in flow equations had been called "friction coefficient" and "friction factor," respectively. However, many authors have used the names of the terms interchangeably, with the result that considerable confusion has existed in the literature on flow of fluids. In an effort to establish a clear and concise terminology for these terms, the authors have designated f as "resistance coefficient" and $(1/f)^{1/2}$ as "transmission factor."

Transmission factors for the flow strings of gas wells were determined by tests on wells in six fields of Oklahoma, Texas, and Louisiana. Data were collected on 14 gas wells while gas was flowing through 1½, 2, 2½, and 3-in. tubing and 5½ and 7-in. casing. The transmission factors developed from these data were found to follow the resistance equation published by Nikuradse for turbulent flow in rough pipes with an average absolute roughness of 0.000,65 in. Authors believe that use of these transmission factors will permit calculation of more accurate subsurface pressures in gas wells than those in use today.
From authors' summary

2182. **Uchida, S., On the non-linear percolation at high Reynolds number,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 437–442.

Differential equation for two-dimensional flow through porous media is linearized by the Molenbroek transformation, as is done by Engelund [AMR **7,** Rev. 2704]. An additional modification enables covering the total range between laminar and turbulent flow.

A solution is given by the Bernoulli method and worked out for the special cases of source or sink and flow around a corner.

To deal with the nonlinearity in percolation, author introduces an empirical formula as an improvement of the Lindquist formula used by Engelund.

Calculations are shown to be in good agreement with results of author's model experiments. H. J. Schoemaker, Holland

2183. **Kheĭn, A. L., Application of the operational calculus to the theory of irregular liquid and gas flow toward uncompleted oil wells** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **95,** 1, 33–36, Mar. 1954.

2184. **Horonjeff, R., and Goldberg, I., Field measurements of soil moisture and density with radioactive materials,** *Nat. Res. Counc. Highway Res. Bd. Proc.*, 32nd Ann. Meet., 500–511, 1953.

2185. **Reynolds, H. R., Notes on the effects of vibrations on soils,** *Civ. Engng. Lond.* **49,** 578, 580; 835–837, 1077–1079, Aug., Oct. 1954.

Micromeritics

(See also Rev. 2040)

2186. **Lang, H. R., edited by, The physics of particle size analysis,** *Brit. J. appl. Phys.*, Suppl. no. 3; London, The Institute of Physics, 1954, 218 pp. 35s.

This indexed collection of 35 papers plus edited discussion includes more than a fairly complete survey of the subject indicated by the title. Several ingenious techniques for counting and sizing particles are described. These employ ordinary and electron microscope, photographic, photoelectric, scattering, and settling techniques. Automatic methods and the training of personnel for routine testing are discussed. Also included are articles on shape and area factors, motion of particles, effective viscosity, dispersion, and elutriation. Aggregation, adsorption, and electrostatic phenomena are considered briefly, and little attention is given to comminution. Most notable omission is the lack of discussion of sampling techniques to assure truly representative samples. W. C. Shaw, USA

2187. **Keller, H., Pressure-drop measurements in porous quartz filters** (in German), *Schweiz. Bauztg.* **72,** 43, 617–619, Oct. 1954.

2188. **Yamada, B., An investigation on the bulking of sand,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 281–290.

2189. **Murayama, S., and Hasaba, S., Segregation of fine and coarse sand grains inside a rotating horizontal cylinder,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 257–260.

2190. **Baum, V. A., Study of fluid mixing processes in currents flowing through tubes filled with coarse material** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 9, 1317–1329, Sept. 1953.

Author studies experimentally the mixing process in parallel filtration flows. He proves that the Fourier-Kirchhoff equation $\partial c/\partial t + u \cdot \text{grad}\, c = \text{div}\,(\epsilon\, \text{grad}\, c)$, or simplified $\partial c/\partial x = \epsilon/|u| \cdot (\partial^2 c/\partial x^2 + \partial^2 c/\partial z^2)$, is satisfied for the smoothed field of concentrations (c is the concentration of one of the fluids; u the effective velocity vector of filtration; ϵ the "filtration-mixing-coefficient," $\epsilon = k\delta\,|u|$ where δ is the grain diameter of the fill, and k a nondimensional coefficient, subject of experimental determination by the author). His experiments were done with water and sodium hyposulphite solution and with fills of different kinds and sizes. Obtained values of k were compared with those by R. A. Bernard and R. H. Wilhelm [*Chem. Engng. Progr.* **46,** no. 5, 1950], with good agreement. Author gives a graph $k(\text{Re}\,\delta)$ (where $\text{Re}\,\delta = |u|\,\delta/\nu$ is Reynolds number referred to grain size), from which he deduces: $0.08 < k < 0.16$ (for lower Re δ) and $0.09 < k < 0.1$ (for higher Re δ), concluding that, in practice, calculations should be available $k = 0.1$ for all $5 < \text{Re}\,\delta < 2000$.

Author calls attention to following details: (1) Coefficient k does not change its value when the current between grains changes from laminar to semiturbulent. (2) Equation keeps validity up to very coarse fill (eight particles in duct width). (3) For accurate measurements, the flow must run downward because, when the opposite occurs, it lifts or moves grains, changing ϵ. (4) The

great pressure drop along filtrating flow suppresses separation and turbulence of main (smoothed) flow; hence no activation of mixing could be obtained with obstacles, cross-section variation, etc.; author proved it with special experiments.

Aside from the mentioned paper in English, four works in Russian (two by the same author) are cited. Reviewer observes usefulness of this study, especially for design of chemical and thermal apparatus; he notes that the constancy of coefficient k gives simplicity and security to the calculations.

N. Krivoshein, Argentina

Geophysics, Meteorology, Oceanography

(See also Revs. 2070, 2073, 2079)

2191. Slichter, L. B., Seismic interpretation theory for an elastic earth, *Proc. roy. Soc. Lond.* (*A*) **224,** 1156, 43–63, June 1954.

For interpretation of seismic data, author considers the problem of an isotropic spherical earth (initially at rest) in which the three independent elastic parameters are supposed to be unknown continuous functions of the radius alone. It is shown that solutions in the form of Taylor's series may be obtained for the variation with depth of each of these parameters when axially symmetrical distribution of surface stresses varying arbitrarily with time is prescribed, it being assumed that the corresponding surface displacements are known functions of time, as determined from observations. For algebraic checks of the results two special examples have been considered. In these two cases the classical ray-path method of interpretation is not applicable.

A. M. Sen Gupta, India

2192. Silberman, I., Planetary waves in the atmosphere, *J. Meteor.* **11,** 1, 27–34, Feb. 1954.

A numerical solution to the barotropic vorticity equation in spherical coordinates is found by fitting it with a stream function expanded in spherical harmonics, producing tendency equations in the harmonic coefficients upon which the iteration is compounded. The scale of the disturbances admitted is controlled by limiting the number of higher harmonics.

This procedure dispenses with the high-order difference equations required by the present practicing schemes of numerical forecasting, which is a large advantage. However, one wonders whether this advantage is not dissipated in the process of fitting spherical harmonics to the initial data. A. Fleischer, USA

Lubrication; Bearings; Wear

(See Revs. 1916, 1917, 1929, 1997)

Marine Engineering Problems

2193. Allan, J. F., and Canham, H. J. S., Ship trial performance and the model prediction, *Quart. Trans. Instn. nav. Arch. Lond.* **96,** 4, 287–296, Oct. 1954.

Paper presents results of thirty-seven ship-model comparison studies made jointly in the United Kingdom by the Ship Division of the National Physics Lab and the British Shipbuilding Research Assn. The wax models were about 18 ft long and were provided with a trip wire for turbulence stimulation. The vessels concerned are all of merchant-ship type and mainly single-screw tankers and dry cargo vessels. Only five of the ships had fully riveted shells; the remaining ships had partly or fully welded shells.

The main conclusions are that there is a reduction of the order of 15% in the power required to propel a ship for the change from completely riveted to completely welded, due to the increased smoothness of the shell. The most favorable results are some 15% below the Froude ehp and some 5% below the Schoeherr ehp for technical smooth surfaces, which may be taken to be impossible. With reference to Hughes' proposed method, however, there is still a substantial reduction in power to be obtained by achieving a really smooth underwater finish. It is clear that the actual roughness of a clean painted ship surface is a matter deserving special study. L. Troost, USA

2194. Völker, H., Systematic variation of usual ship forms, *Inter. Shipbldg. Progr.* **1,** 1, 10–18, 1954.

Author proposes a systematic compilation of ship form characteristics. First, main proportions are treated, then form factors. Following quantities are introduced for considering main proportions: slenderness coefficient $L/\nabla^{1/3}$, length coefficient l, and beam-draft ratio B/D. Treatment of form factors includes block, prismatic, and midship section coefficients, also entrance and run, parallel body, and longitudinal center of buoyancy. Thus article relates to geometric problem alone. How the essential factor of speed influences geometry is not discussed. Author's plea, that future tests be part of one comprehensive international program aimed at relating geometric and dynamic aspects, is strongly endorsed by reviewer. N. H. Jasper, USA

2195. Grim, O., On the stability of periodic forced rolling oscillations of a ship (in German), *Ing.-Arch.* **22,** 1, 55–59, 1954.

For a ship with a low righting arm curve, the differential equation of rolling motion will not be linear. Dr. Grim assumes that the angle of roll can be divided into two parts, one which is periodic and a second one which may not be so. Assuming the righting arm curve to be a third power parabola which has the value zero at a heeling angle φ_k, the equation for the second part of the angle of roll will be a homogeneous Mathieu-type differential equation, for which a stability diagram is produced. The validity of this diagram is discussed for some refinements in the original assumptions. A conclusion of practical importance is that a ship may very well capsize during rolling with an amplitude which is, say, only 80% of the angle φ_k.

G. Vedeler, Norway

2196. Büller, K. J., Flying boats (in German), *Jahrb. Schiffbautech. Gesellsch.* **46,** 119–136, 1952.

2197. Silverleaf, A., and O'Brien, T. P., Some effects of blade section shape on model screw performance, *N. E. Cst. Instn. Engrs. Ship. Trans.* **71,** 4, 123–134, Feb. 1955.

A group of five screws having different blade-section shapes has been designed for a specified loading and compared with a "standard" screw. Water-tunnel tests under cavitating and noncavitating conditions have been made with models of these six screws and the results analyzed to give comparative performance values; some performance values have also been calculated. Under noncavitating conditions no significant differences have been found, but in cavitating conditions causing thrust breakdown, variations in performance have been measured.

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